Editorial

Electrochemistry and Colloids

HOW will electrochemistry serve the world of tomorrow? There are many ways, some examples of which can be cited in their relation to the important field of colloidal phenomena. At Donora, Pennsylvania, twenty persons lost their lives and thousands were made ill by an unsual concentration of industrial smokes and gases in the atmosphere. This pointed up in spectacular fashion the usually lesser but continued damaging effects of atmospheric polution at major centers of industry and population. In terms of our material economy, the over-all cost of these smogs and smokes is estimated as costing this country $1,500,000,000 each year in ruined crops, depreciated property, damage to goods, and lowered productivity. This sum adds to whatever the extended cost may be in terms of health and happiness.

Electrochemistry enters this story from the time F. G. Cottrell arranged a practical precipitator for clearing up smokes and dusts. Beginning in 1906, he successfully applied what was known earlier concerning the migration of colloidal particles in an electric field. The process is the same as that used to plate out rubber from its colloidal solution, known as latex, in which negatively charged micelles migrate toward the anode where they lose their charge. There they coagulate to form solid continuous rubber articles that can be made to adhere to the metal anode or be stripped off. In the case of smokes, the discharged colloids agglomerate to form gross particles easily settled out of the gas stream. The Cottrell precipitator first proved itself in recovering valuable constituents of smelter dusts, or eliminating dust from efflux gases of cement factories, or precipitating mists of sulfur trioxide from outgoing gases of a sulfuric acid plant. Increasingly, however, these precipitators are being used to eliminate smoke

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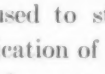
particles from belching chimneys and thus rid our cities once and for all of the dark man-made clouds that hover over streets and buildings. The Cottrell precipitator is probably one of the most important applications of electrochemistry to colloidal phenomena.

Another application is in the field of ceramics where similar electric fields are used to separate water from clay in competition with drying methods applying heat. The same process finds application in lubrication of dies for the extrusion of clay slurries making use of the fact that when the colloid migrates toward the anode, a water film remains at the cathode effectively easing flow of the slurry. Along the same lines, this principle is applicable to the age-old occupation of plowing the soil, where it is said to ease a plow through the ground with 30% less friction. Recent reports from England inform us that this phenomenon, called electro-endosmosis, is also being used to stabilize soils upon which to erect foundations for buildings. By application of an electric field, colloidal soil particles are made compact by squeezing out water, thereby making the soil a better base. The above list is not complete, but it indicates far-reaching contributions of electrochemistry to the technical field of colloids, important to everyday living.



Technical Notes and Reviews

Review of "Forum on Corrosion Research" held at Washington, D. C., Nov. 9-10, 1949

J. J. Harwood* and Fred Schulman**

In a recent address before the United Nations Scientific Conference on the Conservation and Utilization of Resources (1), Dr. H. H. Uhlig emphasized the staggering cost of corrosion to our national economy (approximately five and one-half billion dollars annually) and indicated the value to be realized from an adequate research and development program which may lead to the control of corrosion.

The literature abounds in empirical data of limited usefulness but is relatively meager with respect to basic information concerning corrosion theories and processes. In view of the potential gains which would accrue from a more thorough understanding of corrosion mechanisms and kinetics it is indeed surprising that such little effort has been expended in the past on the scientific study of corrosion. Certainly, as Dr. Uhlig implied, the opportunities for success are almost unlimited. The Federal Government through its various agencies shares with industry a deep interest in this problem and has taken an active part in the fight against corrosion by supporting a comprehensive basic research program in several leading institutions.

Since this research program may be of some interest to the members of the Society a brief review is given of the progress reported at the "Forum of Corrosion Research" held at the National Academy of Science in Washington on November 9 and 10, 1949, under the sponsorship of the Office of Naval Research (ONR). Participating in this conference were university scientists engaged in fundamental research in corrosion and related electrochemical research under government contract. As the major portion of the research to be discussed is supported by the Office of Naval Research it may be well to describe briefly the organization and functions of ONR.

The second World War taught the Navy that military engineering can best be advanced through the application of modern science. It taught that military preparedness and the solutions to many of its practical problems could best be achieved through the creation of a large store of basic knowledge upon which the Navy can draw. For these reasons, ONR was permanently established by Congress in August, 1946, and is charged with the over-all responsibility for the Navy's scientific research program. For the past four years ONR has been sponsoring a broad, long range program in fundamental research covering practically all branches of the physical, chemical, biological, and mathematical sciences. The program is executed largely by means of research contracts with academic, industrial, private, and government laboratories. Equally important functions are the coordination of the scientific research effort throughout the Navy and the dissemination of research information resulting from such endeavors.

In view of the Navy's vital interest in corrosion, it seems only natural that a constituent part of such a comprehensive research program should be devoted to the understanding of why metals do or do not corrode. The ONR corrosion research program, which has been described in some detail elsewhere (2), is aimed at the study and elucidation of the fundamental mechanisms and kinetics of corrosion reactions and supports the more practical and applied studies under way in the various naval bureaus and laboratories.

The purpose of the "Forum on Corrosion Research" was to acquaint the scientific personnel of the National Military Establishment and other government agencies with the fundamental corrosion studies supported by government contract in order to provide a review of some of the most recent thinking and progress in the science and theory of corrosion. Some of the work described at the Forum is being supported by the Bureau of Ordnance of the Navy Department, by the Signal Corps of the Department of the Army, and by the Atomic Energy Commission. Appreciation is expressed to these agencies for their cooperation in arranging the Forum.

The papers were presented in four sessions as follows:

1. Electrochemical Fundamentals
2. Passivity and Inhibitor Studies
3. Corrosion Mechanisms and Kinetics
4. High Temperature Corrosion

Research on Electrochemical Fundamentals

Professor David C. Grahame of Amherst College opened the discussion by presenting the results of his research, under ONR sponsorship on the nature of the electrical double layer. The structure of this layer is intimately connected with the mechanism of electrolysis and with the transfer of electrons from metal to solution. Measurement of the electrical capacity of this double layer yields thermodynamic information concerning the concentration of ions within the double layer. This can be combined with kinetic studies to obtain evidence on the structure of the system (3).

With respect to the metal interface two planes are of importance within the solution phase. The *inner* Helmholtz plane is the locus of the centers of adsorbed anions; the *outer* Helmholtz plane, slightly farther removed, is the distance of closest approach of hydrated cations. These cations form an ionic atmosphere which makes up the diffuse region of the double layer. Within the diffuse double layer there is a deficiency of anions. It is possible, of course, for

* Metallurgist, Materials Branch, Office of Naval Research, Washington, D. C.

** Chemist, Chemistry Branch, Office of Naval Research, Washington, D. C.

the role of the cations and anions to be reversed as when the metal is positively charged and the anions are poorly chemisorbed.

It was found that all the monatomic cations studied showed astonishingly similar properties in the electrical double layer (Fig. 1). The experiments indicate that the cations, Li^+, Na^+, K^+, Rb^+, Cs^+, Ca^{++}, Ba^{++}, Sr^{++}, Mn^{++}, Mg^{++}, Co^{++}, Ni^{++}, Al^{+++}, La^{+++}, H_3O^+, and NH_4^+ remain hydrated within the double layer. Many anions, on the other hand, are easily dehydrated at a metallic surface resulting in close approach of the anions to the surface of electrolysis, the electrons would be required to pass through the cationic solvent sheath. Such a process is normally expected to require an energy of activation. Yet, with the exception of hydrogen ion, simple cations are known to be reduced without activation energy. A mechanism has been proposed by Professor Grahame to account for this apparent anomaly. It is anticipated that further study of the electrical double layer may aid in the interpretation and solution of some of the perplexing questions in electrochemistry and corrosion.

Professor D. MacGillavry Jr. of Clark

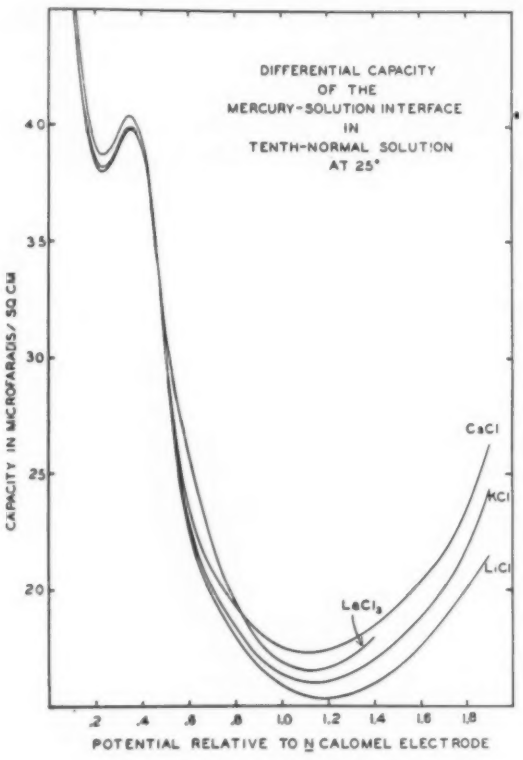


FIG. 1. (D. C. Grahame)

and formation of covalent bonds with the metal.

Capillary-active substances accumulate at the interface between a metal and a solution when the metal is not too greatly charged. This effect may account for the corrosion-inhibiting properties of many of these compounds and suggests that the inhibition may be reduced or removed if the potential of the metal relative to the solution goes too far positive. As might be expected, these layers of capillary-active materials profoundly affect the capacity of the double layer and the hydrogen overvoltage.

It should be noted that in the process

University reported on some aspects of his ONR supported research on metal-solution interface potentials. This work may provide much needed information on the potentials of metals in solutions containing no common ions.

Refinements in experimental technique have been essential requirements of this research in order to preclude the possibility of solution of ions from the metal during potential measurements. Thus a potentiometer was ruled out in favor of a vacuum tube electrometer. Degassed electrodes of platinum, gold, and nickel were studied in contact with buffered solutions of various pH's. In spite of carefully controlled experimental conditions, duplicate electrodes did not give identical potentials. However steady state time-potential curves were obtained and could be held within a few millivolts. It was found that pH_2 electrode pretreatment, and presence of air have marked effects on the potentials of the platinum-phosphate buffer system. The series of measurements on nickel give steady potentials in the absence of oxygen and varying potentials in the presence of oxygen. The results appear to support the following conclusions:

(*a*) Nickel does not possess a measurable solution pressure.

(*b*) Nickel slowly adsorbs oxygen forming a gradually spreading surface oxide layer, which is the only process taking place when nickel is in contact with alkaline solutions.

(*c*) Nickel oxide does not react with water.

(*d*) Metallic nickel does not react at room temperature with either water or hydroxyl ion.

These properties appear to account for the corrosion resistance of nickel in alkaline solutions.

For the past three years, ONR has supported the research of Professor Pierre Van Rysselberghe at the University of Oregon on polarographic studies of corrosion phenomena. During this period Dr. Van Rysselberghe has been able to demonstrate the wide applicability and usefulness of the polarographic method in following corrosion reactions. The method lends itself not only to the detection of metallic ions, but also to the determination of oxygen consumption by metals immersed in aqueous media and to the determination of hydrogen ions, carbon dioxide, hydrogen peroxide, and similar reactants. Details of the method and the discovery of the percarbonic acid reduction wave in corrosion reactions have been described elsewhere (4). It was found that carbon dioxide has a definite effect on the reduction process of oxygen at the mercury cathode due to percarbonic acid formation. It is possible that a percarbonic acid mechanism may exist whenever hydrogen peroxide is formed in the presence of carbon dioxide. Percarbonic acid appears to be more easily reducible than hydrogen peroxide and acts therefore as a more effective cathodic depolarizer than oxygen itself. There is also the possibility that carbon dioxide can act in cyclic processes by which percarbonic acid is formed and then reduced, the

reduction product decomposing again to carbon dioxide which is then available for reaction with hydrogen peroxide.

Dr. Van Rysselberghe has studied the oxygen consumption and corrosion characteristics of a number of metals and their alloys by his polarographic method. It was found that aluminum, zinc, and magnesium favor hydrogen peroxide formation. This suggests that the presence of carbon dioxide may have an important effect on the corrosion rate of these three metals and their alloys. On the other hand, the presence of hydrogen peroxide was not detected when oxygen was reduced in the presence of copper, iron, nickel, lead, or tin. In the course of the work several unique electronic polarographic instruments have been developed (5, 6).

One of the important applications of this work is the possibility of predicting the minimum effective concentration of inhibitors. This may be done by noting the oxygen consumption polarographically as the concentration of inhibitor in a solution is increased. These studies are being conducted at present on iron, steel, and aluminum with various concentrations of sodium nitrite and chromate as inhibitor.

Passivity and Inhibitor Studies

Most metals and alloys depend upon the formation of protective surface films (passivation) for practical use under corrosive conditions at normal and elevated temperatures. Breakdown of these films results in corrosion failure. It seems obvious, therefore, that a knowledge of the mechanisms of passivity and the factors influencing the formation, nature, and breakdown of protective films is essential to the complete understanding of corrosion phenomena. Since the time of Faraday, the phenomenon of passivity has been the subject of much speculation and experimentation with no universally acceptable general theory as yet proposed. Thus an important phase of the government research program in corrosion is concerned with developing a truer understanding of passivity and inhibitor action.

At Massachusetts Institute of Technology, Professor H. H. Uhlig (under ONR contract) is studying the relationships between electron sharing in the transition metals and passivity. Dr. Uhlig is a leading proponent of the mechanism of passivity in metals like chromium and the stainless steels which ascribes protection to an adsorbed (chemisorbed) atomic or molecular monolayer. The adsorbed film is protective because of satisfaction of chemical valences of both the substance adsorbed and the metal surface, but without dislodging metal atoms from their lattice. In his paper "Electron Sharing and the Nature of Passivity," Dr. Uhlig pointed out that only those substances adsorb on a metal surface for which reaction with the metal to form a new lattice involves an activation energy. This is the condition necessary for chemisorption and implies that if no activation energy is involved, passivity does not exist. Whether an immediate reaction of metal occurs with its environment or adsorption occurs followed by a delayed reaction appear to be functions of both the work function of the metal (case of extraction of an electron) and the heat of sublimation (case of extraction of a metal atom from its lattice). If the heat of sublimation is high relative to the work function, the metal adsorbs oxygen and becomes spontaneously passive. Oxide formation is considerably delayed in such cases, e.g., tungsten, chromium, nickel, stainless steels.

Since according to the electron configuration theory of passivity, activation energy, therefore, is related to passivity, the equation of Rideal and Jones

$$\Delta E = \phi - K$$

where ΔE is the energy of activation for oxidation, ϕ is the work function of the metal, and K is a constant equal to 3.6 electron volts, reveals empirically that high work function is favorable to passivity. In support of the effect of electron configuration on passivity, Dr. Uhlig has demonstrated that iron can be made passive by physical contact with chromium (7). The electron sharing between chromium and iron presumably so changes the work function and the sublimation energy of the iron layer at the interface, that in the presence of oxygen and water the activation energy for reaction is positive, whereas for iron alone the activation energy is zero. Similar effects occur when chromium is alloyed with iron.

Other supporting evidence lies in the correlation of changes in oxidation rates with changes in work function. The work function differs above and below the Curie Point; therefore from the above equation one should expect a corresponding change in energy of activation for oxidation. This has been demonstrated by Dr. Uhlig for a series of chromium-iron alloys, as shown in Fig. 2. The data establish that an electronic transition in chromium-iron alloys affects the activation energy, and thus can also affect passivity.

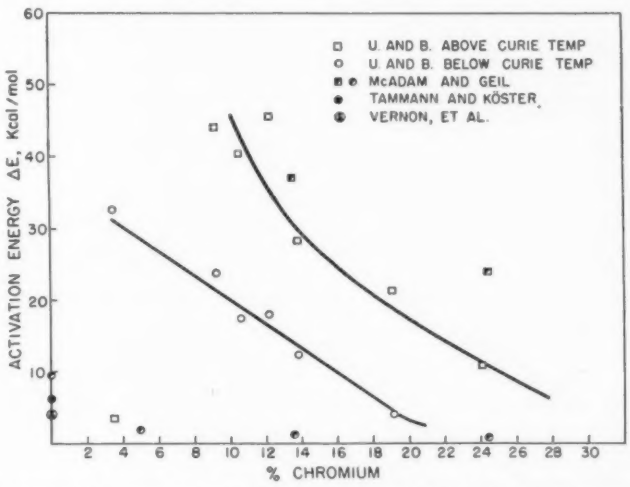


FIG. 2. Activation energies of oxidation above and below the Curie temperatures for Cr-Fe alloys (Brasunas and Uhlig).

Along the same lines, studies were reported pertaining to the question whether films on stainless steels are monolayers or multilayers. By evaluating the true surface area of pickled 18-8 (which is roughly 15 × the apparent area) it has been demonstrated that the thickness of films built up on freshly pickled stainless steels is probably not greater than a monolayer after 30-minute exposure to oxygenated water. The work is continuing using various pickling acids, and includes the effect of cathodic polarization on oxygen consumption.

Work on the intermetallic compounds of magnesium and copper is also under

way, as well as the study of the contact potentials of copper-nickel alloys and other metals and alloys.

Professor Norman Hackerman of the University of Texas reported on his "Passivity, Exchange Adsorption and Inhibitor" studies being conducted in cooperation with ONR. Dr. Hackerman also is approaching the problem of corrosion reactions from the point of view of surface effects, e.g., adsorption. His studies are based upon the viewpoint that the effect of solid surface is a major consideration, not only with respect to the real surface area but also with respect to the nature of the surface. The nonhomogeneity concept of solid surface, resulting in local anodic and cathodic areas, is implicit in the electrochemical theory of corrosion. However, Dr. Hackerman pointed out that it is not necessary to assume equal activity of all of the atoms contained in either the anodic or cathodic areas. It is possible to conceive of a distribution of activities such that, in a given time interval, some surface atoms are continually anodic, others continually cathodic, and still others may be either anodic or cathodic depending on fluctuations in local conditions. This heterogeneity is maintained during the corrosion process as a result of local variations in pH, electrical resistance, polarization, nature of reaction products, etc., produced during localized reactions. The studies described were concerned largely with sorption on metals from solutions and from the vapor or gas phase.

The adsorption of polar organic solutes in benzene solution on steel powders was determined for several monosubstituted homologous series by measuring the weight increase of the powder. The total uptake was a function of the molecular weight of the solute and was only slightly affected by the nature of the functional group. A portion of the sorbed material was not removable by washing. The amount of this firmly-held sorbate was practically independent of molecular weight, but was clearly related to the nature of the functional group. The order for decreasing stability of adsorption as well as total adsorption was acid > amine > alcohol > ester. The data also indicated that for some of the functional groups, sorption took place on common sites while for others, although there was some overlap, noncommon sites were involved. Acids and alcohols typify the former, while acids and amines are examples of the latter.

It was found that the firmly sorbed material produced a reduction in the reactivity of the powder in HCl as compared to untreated powder. The polar organic inhibitor apparently had two functions: (*a*) to prevent access of corrosive agent by simple barrier action of physically sorbed material, and (*b*) to reduce the activity of those atoms in the metal surface on which it is irreversibly sorbed. This line of reasoning is being pursued further using solid metals in aqueous systems with radioactive carbon 14 in the carboxyl group of stearic acid.

The effect of polar organic additives on steady state electrode potentials of SAE 1020 steel using 1*N* H_2SO_4 and amine additives has also been studied. The potential changes are interpreted in terms of adsorption on the electrodes. In almost all cases the potential was more cathodic in the presence of the additive, the extent of the shift depending on the nature of the amine and on its concentration. The results indicated the occurrence of some anodic polarization. Polarizing the anodes at a constant current revealed that in the presence of amines, anodically polarized steel becomes more cathodic and cathodically polarized steel becomes more anodic. This was interpreted as being caused by increased current density brought about by metal area decrease as a result of adsorption. It was concluded that organic inhibitors produce effects more general than at cathodic areas only.

Work is also under way on the effect of chloride, sulfate, and chromate ions separately and in combination, on passive metal surfaces such as chromium. Radioactive tracers are being employed and exchange reactions between the anions are being studied.

Discussion of "Passivity Studies on Stainless Steel and other Metal Systems" was presented by Professor M. G. Fontana of Ohio State University who also has a research contract with ONR. Detailed information concerning the program has been presented in references (8) and (9). Professor Fontana emphasized that passivity is a relative term—an alloy could show no attack in one medium and violent reaction in another. Based mainly on studies of 18-8S, a theory has been postulated to the effect that a passive surface is delicate in nature, easily destroyed, and may be due to a physically adsorbed gas. A hydrous oxide film may aid in the gas adsorption. Chemical combination or compound formation is not required. Passivation of 18-8S stainless has been accomplished by pickling in sulfuric acid, hydrochloric acid, lactic acid, acetic acid, etc., followed by exposure to air. Such passivation can be broken down by exposure to vacuum at room temperature. Repassivation occurs, however, upon exposure to air, and the breaking down and repassivation can be continued indefinitely by alternate exposure to low pressure (vacuum) and to air. Specimens given the "sulfuric acid-air" passivation treatment exhibited no pitting in corrosion tests in synthetic ocean water, whereas pitting occurred on specimens which had been passivated by treatment with nitric acid and dichromate-nitric acid.

Potential measurements were demonstrated to be a poor yardstick for measuring "degree" of passivity and the mere presence of a film is not a sufficient criterion of passivity since films can be stripped from both active and passive surfaces. A gamma 18-8 structure was more amenable to passivity than an alpha structure which is produced by abrading 18-8 specimens. Diffuse electron diffraction patterns indicated that the passive film was not crystalline and may be a hydrous oxide.

The delicacy of the passive film was demonstrated by (*a*) breaking down in vacuum at room temperature, (*b*) activation of the specimen by touching the surface with an iron wire, and (*c*) activation by light scratching. The sensitivity of passivity is also indicated by the ease with which localized corrosion can occur in stainless steels. The question of passivity being caused by a physically adsorbed gas was discussed and doubt was expressed whether such is actually the situation, since physical adsorption does not occur readily at room temperature. It was postulated that the passivity may have resulted from the entrapment of gas in the porous oxide film, thus providing a physical barrier.

Passivity studies on titanium, high-silicon iron, lead, copper alloys, and other metals are also under way. In the case of titanium and silicon, evidence of oxide films has been obtained. Studies of grain boundary potentials in several metals and alloys are also being conducted.

Corrosion Mechanisms and Kinetics

The contribution of thermodynamics to the study of corrosion processes was presented in a paper by Professors D. S. McKinney and J. C. Warner of Carnegie Institute of Technology, working under contract with the U. S. Atomic Energy Commission. Thermodynamic information, if available, is useful in two ways:

(*a*) it excludes from consideration those reactions which are impossible, and (*b*) it provides information necessary to treat the corroding medium so as to maintain the passive film, thus preventing or at least greatly decreasing corrosion.

The free energy changes for the possible corrosion reactions are, of course, the most essential thermodynamic data. They are obtained by three general types of experiments: (*a*) measurement of the electromotive force of reversible cells, (*b*) direct measurement of equilibrium constants, and (*c*) thermal measurements. For practical reasons however, none of the three general methods for obtaining the free energy is universally applicable. Furthermore, the physical state of the substances is frequently not the same as that met in corrosion reactions. It is, therefore, necessary to use due caution in the interpretation of thermodynamic data. The use of free-energy information may be illustrated by the corrosion of iron in oxygen-free water. Of the possible reactions, the conversion of iron to ferric hydroxide at ordinary temperatures is accompanied by an increase in free energy. This means that this reaction cannot take place and that ferric hydroxide may be ruled out as a corrosion product.

In order to make full use of thermodynamic information, it is often necessary to know the magnitude of irreversible effects at electrodes, solubilities of corrosion products, dissociation constants of complex ions and acids, and similar properties so that the environment may be altered in favor of producing protective corrosion products. At Carnegie Tech, therefore, Professors McKinney and Warner are investigating a number of problems which may result in more widespread applicability of thermodynamic data. Some of these problems are: (*a*) reversal in potential of zinc-iron couples at elevated temperatures, (*b*) solubility of $Zn(OH)_2$ as a function of temperature and pH, (*c*) reaction of solid $Zn(OH)_2$ with carbon dioxide, and (*d*) polarization characteristics of titanium and zirconium. They find that in an aerated Zn-Fe cell, reversal cannot be produced by a change of pH. The hydrogen overvoltage on titanium has been found to be quite high, about the order of that of zinc. In $0.1N$ H_2SO_4 solution, titanium shows high anodic polarization even at low current densities. The anodic film, probably the oxide, has very high resistance. Drs. McKinney and Warner feel that the stainless properties of titanium are due to the presence of this film.

An attempt to obtain a more satisfactory understanding of the several factors which control the mechanism of bimetallic corrosion was the aim of an ONR research contract at the University of Colorado under the direction of Professor Carl W. Borgmann. Dr. Borgmann and Dr. R. T. Koenig made weight loss and electrochemical studies on a number of bimetallic systems in solutions containing 3.5 per cent NaCl, 500 ppm NaCl, 50 ppm NaCl, or 500 ppm $CaCl_2$. The following metals were used: mild steel, zinc, copper, 68-32 brass, 8 per cent tin bronze, nickel, monel, 18-8 stainless steel, aluminum alloys 2S, 17S, and 24S, and a magnesium alloy containing 1.5 per cent aluminum. Various anode to cathode area ratios were employed. A novel feature of this research was the homogeneity of the bimetallic samples. These samples in the form of rods or annular rings were so prepared as to minimize spurious metallic junction effects.

It was found that the corrosion rate of iron coupled with noble metals such as copper, nickel, and chromium totally immersed in the above solutions was independent of the area ratio of the two metals and is little influenced by the concentration of salt in the solution. Under conditions of total immersion therefore, the rate of corrosion appears to be dependent upon diffusion of oxygen through the solution to the corroding iron. Corrosion of zinc coupled to copper shows similar characteristics. However, the rate of corrosion of zinc is increased markedly when in contact with nickel, iron, or chromium. In these cases hydrogen evolution replaces oxygen diffusion as the controlling corrosion mechanism. The loss of weight of zinc is dependent upon the area ratio, nature of the noble metal, (particularly its hydrogen overvoltage), and upon the solution concentration. When the specimens were only partially immersed (with noble metals uppermost) in the corrosion medium, the results were quite different from those obtained in the total immersion experiments.

Polarization curves of bimetallic couples are difficult to interpret because of the complexity of the systems. An investigation of the effects of environment and the nature of electrodes on these curves, may provide information which will aid in the reliable interpretation of polarization characteristics of bimetallic systems.

Dr. George R. Hill stressed the importance of determining the kinetics of initial reaction of the corrosion process in his paper entitled, "Corrosion of Metals in Contact with Liquids." The objectives of this research, conducted with ONR support, are to determine the mechanism, activation energy, and absolute rate constant of the intial rate-controlling chemical reaction. In the corrosion of electrolytic copper in oxygen-saturated normal potassium chloride at 25°C, the initial chemical reaction appears to be rate-controlling only for the first two or three minutes of the corrosion process, after which diffusion of products from the surface of the metal or diffusion of ions through the surface film is rate determining.

It was found that cleaning the copper specimen in ammonium persulfate solution effectively removed all traces of surface film, while cleaning by abrasion left a film consisting of three compounds as detected by electroreduction. After cleaning and determination of apparent surface area, the sample is suspended in a thermostated, stirred solution of known pH, oxygen concentration, and salt concentration for a measured time. The thickness of the surface film is measured by electroreducing the sample while measuring the potential of the cell. Use of the following equation gives the surface film thickness:

$$T = \frac{it\,\frac{M}{F\,\frac{n}{D}}}{a}$$

where i is the current in milliamperes, t is the time in seconds, F is the faraday, M is the gram molecular weight of the compound composing the film, n is the number of faradays required to reduce one gram molecular weight of the film, D is the film density, and a is the area of the metal in square centimeters.

Dr. Hill discussed the factors which affect the thickness of corrosion films on copper, including pH and adsorption of acetate ion. He plans to measure: (*a*) temperature coefficients for these reactions in order to determine the heat of activation for the chemically slow initial process, (*b*) effects of dissolved gases such as carbon dioxide and sulfur dioxide, (*c*) the nature of acetate inhibition, and (*d*) the nature and formula of the activated complex. Results of the corrosion of copper in KCl at pH 7 is shown in Fig. 3. The absolute reaction rate for the initial linear portion of the curve is 2.7×10^{-4}/sec/dm^2.

Dr. Walter Beck of Lehigh University discussed two phases of his research sponsored by the Army Signal Corps. These were: (*a*) "The Dissolution of

Magnesium in Hydrochloric Acid," and (*b*) "The Effect of Oxygen Concentration on the Corrosion of Aluminum." Dr. Beck is also investigating the corrosion of aluminum under accelerated conditions.

In this investigation, the dissolution of high purity magnesium in hydrochloric acid has been studied by measuring dissolution rates and electrode potentials as functions of the acid concentration, temperature, and rate of agitation. At high acid concentrations (1.4*N*) vigorous stirring has no effect on the dissolution rate. At lower concentrations of acid, agitation has a considerable influence on the observed corrosion, the dissolution rates being proportional to the acid concentration and speed of rotation. The studies of electrode potentials indicate that the change in potential of magnesium toward more cathodic values with decreasing dissolution rate may be due to a gradual covering of the surface by replated low overvoltage impurities from the metal.

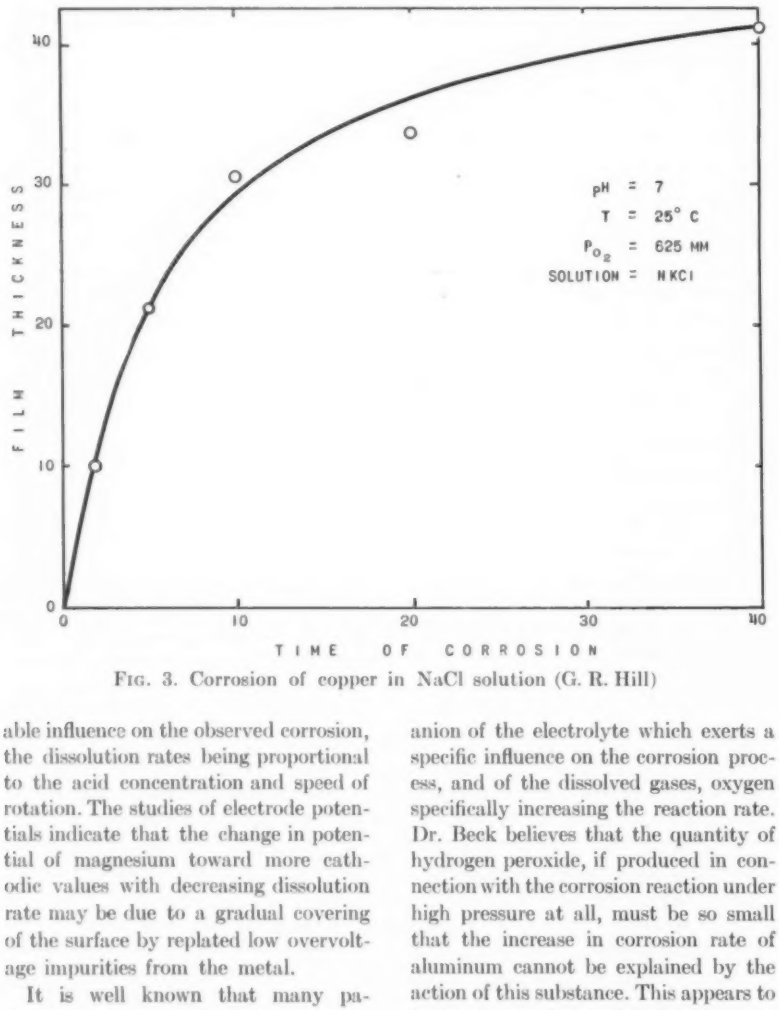


FIG. 3. Corrosion of copper in NaCl solution (G. R. Hill)

It is well known that many parameters are important in the corrosion of aluminum in electrolyte solutions. In order to clarify much of the existing confusion with respect to some of these factors, Dr. Beck has undertaken a comprehensive investigation of the effects of concentration of electrolyte and dissolved oxygen concentration on the corrosion of aluminum while keeping constant such parameters as valence of the dissolved anion and cation, pH, film formation on metal surface, temperature, depth of immersion, orientation of specimen in solution and its surface area, motion of sample, and volume of corroding solution. Oxygen was bubbled through the solution, or the test solution with specimen immersed was exposed to an oxygen pressure of 150 psi in an autoclave. It was found that the rate of corrosion of aluminum increased with increasing amounts of oxygen dissolved in KCl solutions over the concentration range from 0.0001*N* to 1*N* KCl. The experiments also indicated that it is the anion of the electrolyte which exerts a specific influence on the corrosion process, and of the dissolved gases, oxygen specifically increasing the reaction rate. Dr. Beck believes that the quantity of hydrogen peroxide, if produced in connection with the corrosion reaction under high pressure at all, must be so small that the increase in corrosion rate of aluminum cannot be explained by the action of this substance. This appears to be at some variance with the finding of Van Rysselberghe that the corrosion of aluminum proceeds through a percarbonic acid mechanism in the presence of carbon dioxide.

Changes in electrode potential were also recorded along with the variations in O_2 pressure and solution concentration. As the oxygen pressure increased, the potential first rapidly increased in the anodic direction, then leveled off followed by a slow but continual cathodic change of potential.

While the data thus far obtained are insufficient to attempt a full interpretation, Dr. Beck pointed out that it was the objective of this and future research to establish a comprehensive mechanism concerning the corrosion of aluminum in any given electrolytic solution in the presence of dissolved oxygen.

High Temperature Corrosion Studies

Dr. M. T. Simnad of Carnegie Institute of Technology opened this session by presenting a brief review of the experiments being carried out at the Metals Research Laboratory, under ONR sponsorship, on the high temperature oxidation of metals. The main object of this work is to elucidate the kinetics and mechanisms of the oxidation of metals and alloys from the viewpoint of diffusion and phase changes taking place in the oxides. Iron, titanium, copper-platinum, and copper-palladium have been studied. In some studies, radioactive tracers are used.

Dr. Simnad pointed out that the oxidation of a metal at high temperatures is determined mainly by two factors: (*a*) the rate of reaction between the diffusing material and the other reactant at the particular interface, and (*b*) the rates of diffusion through the oxide phases. The main object of the work on the scaling of iron is to determine the variation of composition in the scale with thickness and its dependence on the time and temperature of oxidation. The influence of phase changes taking place, both in the scale (at 570°C) and in the metal (at 906°C), on the oxidation rate is being studied. The results to date indicate that within the temperature range of 600°–1000°C the parabolic law is obeyed with a change in rate constant at about 906°C. It has been postulated that the only mechanism required for the process is the diffusion of iron atoms through the vacancies in the iron lattice, and that the structure of the interfaces between the phases is a governing factor in determining the kinetics of the formation of scale. Interestingly enough, when the metal was allowed to oxidize completely, the scale continued to gain weight. This aspect of the subject, the oxidation of oxides, is being pursued further.

The oxidation behavior of titanium at high temperatures is being studied to

determine the structure, composition, and rate of growth of the oxide phase.

With the copper-palladium alloys, only the copper oxidizes, and the results indicate the presence of both an external and an internal zone (subscale) of oxidation which coexist at all alloy concentrations. Both zones were found to grow in accordance with the parabolic law. The parabolic behavior is in agreement with Wagner's concept of a stationary concentration in the metal phase at the scale/subscale interface. The growth of the external scale is associated with the diffusion of copper through the scale and the rate of supply of copper to the scale/subscale interface by diffusion in the metal phase.

It may be of interest to report that the Metals Research Laboratory is also engaged in the study of the influence of stress on metal-ion exchange in solution using radioactive cobalt, as well as the study of the mechanism of carbide formation in stainless steels and of passivity of these steels in chromate solutions.

A similar approach to high temperature reactions was discussed by Professor W. J. Moore of Catholic University. Working under Bureau of Ordnance, Navy Department contract, his group has been engaged in a study of the fundamental physicochemical factors underlying the corrosion and erosion of metals at high temperatures. The work has included kinetic investigations of the rate of surface film formation on metals, measurements of diffusion in solids by means of radioactive tracer techniques, and a study of the electrical properties of semi-conducting oxide films.

Preliminary studies showed that when clean metals were exposed to oxygen at elevated temperature, the rapid exothermic reaction caused a large rise in the temperature of the metal surface. Thus in the reaction kinetics studies, in order to obviate this source of uncertainty, the specimens were pretreated by the formation of a low temperature oxide film. While the intial conditions of the experiment were thereby changed, the change was readily provided for in the integrated form of the rate equation:

$$\overline{\Delta y} = \frac{2kt}{\Delta y} - 2y_0$$

in which Δy is the increase in film thickness and y_0 is the intial film thickness. The parabolic law leads to a linear plot of Δy vs. $t/\Delta y$, the slope of the line giving the rate constant k, and the intercept giving the initial film thickness y_0.

Professor Moore presented experimental data on the oxidation of zinc and nickel foil and discussed the transition state theory for the oxidation of metals.

Professor D. D. Cubicciotti of Illinois Institute of Technology reviewed his research program on the study of the kinetics of gas-metal reactions which is being supported by ONR.

Beryllium oxidizes in accordance with the parabolic law and at the end of the run was covered with a pearl-grey protective oxide layer. The reactions were quite slow and temperatures of 850°–950°C were necessary to produce the oxide. In the temperature range of 600°–920°C, zirconium also oxidized according to the parabolic law and at all temperatures zirconium dioxide was formed. The nonlinearity of the plot of rate constant vs. reciprocal of temperature indicated that zirconium was reacting with oxygen by a two-stage process: (*a*) dissolving oxygen to form a solid solution of oxide in the metal, and (*b*) forming zirconium dioxide.

The reaction of zirconium with nitrogen is somewhat similar to the reaction with oxygen. For short reaction times (< 3 hr), the reaction is parabolic, but the rates become more rapid as the reaction proceeds. The permeability of zirconium to hydrogen at high temperatures was also studied.

From a consideration of the derivation from the parabolic equation, Professor Cubicciotti postulated that the rate constant should depend on the solubility of the metal in the oxide formed. A metal that is little soluble in its oxide should be slower oxidizing than one that is very soluble. From a comparison of solubility of metals in their chlorides, which were previously determined (10), divalent metals should be less soluble than higher valence metals in their oxides, and for a given valence type the smaller the cationic diameter, the lower the solubility. Thus beryllium should be the slowest oxidizing metal. Silicon should be slower than zirconium, but faster than beryllium. These expectations seem to be fulfilled by experimental evidence.

Oxidation studies of stainless steels were described by Professor M. G. Fontana of Ohio State University. Under ONR contract, he has been studying the oxidation behavior of type 304 (18-8S), type 430 (17% Cr) and type 410 (12.5% Cr).

For type 304, oxidation first follows the parabolic law, then the rate of oxidation increases abruptly. The time before the break occurs depends on the partial pressure of oxygen and on the temperature. For example, the change in rate occurs after 3 hours at 1700°F with no break at 1500°F and 1600°F. For types 430 and 410, the break occurs at 20 minutes and 10 minutes respectively. The apparent explanation for these abrupt changes in oxidation rates is that rupture of the scale occurs and relatively rapid oxidation takes place at the ruptured areas. The scale forms nodules and the base metal pits at these points.

A difference in oxidation behavior for type 410 was observed within the temperature ranges of 1500°F–1800°F. In addition to being caused by temperature effects, the differences may be related to the fact that an α iron structure exists at the lower temperatures whereas at the higher temperatures α plus γ coexist.

During the period of rapid oxidation the chromium content of the scale decreases and the iron content increases. Electron diffraction studies show the presence of Fe_3O_4 type spinel before the break and Fe_2O_3 afterward. It is believed from a combination of all the observed results that $FeO \cdot Cr_2O_3$ spinel forms first and then Fe_2O_3 is the predominant oxide which is formed.

Pre-oxidation treatments to form selected oxides show that the $FeO \cdot Cr_2O_3$ scale is more protective than the alpha Fe_2O_3 scale. The former occurs under "starved" oxidation conditions (i.e., low oxygen and/or temperature) and the latter with more aggressive environments as far as oxidation is concerned.

Other studies on titanium-chromium alloys revealed that Cr additions up to 16 per cent are detrimental to the oxidation resistance of Ti. Above 16 per cent Cr, improved oxidation resistance is obtained. Similar results for Mo-Cr alloys have been reported by other investigators. The Ti-Cr alloys form double layer scales, the inner layer rich in chrome oxides and the outer layer rich in titanium oxides.

It has been found that the presence of molybdenum in high temperature (e.g., 16-25-6 Mo alloy) results in very rapid and destructive oxidation in stagnant atmospheres. If the MoO_3 vapors are swept away, as in circulating atmospheres, more normal rates of oxidation for these alloys are observed.

In a review of his elevated temperature-oxidation studies, Dr. H. H. Uhlig pointed out that relatively thick adherent oxide layers are protective because of the difficulty with which metal ions and electrons move outward through the oxide or with which lattice

vacancies and positive holes move inward. The more resistant oxides are more effective diffusion barriers or electric insulators. Dr. Uhlig described a demonstration of the fact that metal ions move outward rather than oxygen diffusing inward, observed by A. deS. Brasunas of the M.I.T. Corrosion Laboratory. In the complete oxidation of a steel containing 2 per cent Si, 2 per cent Al, and low carbon, a hole was found in the center of the remaining oxide almost identical with the dimensions of the original metal specimen measuring $\frac{7}{16}$ in. in diameter by $\frac{1}{2}$ in. deep. This is shown in Fig. 4.

Chromium is one of the most effective elements for increasing oxidation resistance. Increasing resistance is apparently related to the chromium content of the oxide, since chemical analyses indicate that chromium concentrates in the oxide in greater proportion than it exists in the metal. It therefore appeared reasonable that substantial improvement of the resistance low-chromium iron alloys could be accomplished by forming artificially a surface oxide high in chromium. This can be done by preferential oxidation of the chromium. For example, moist hydrogen oxidizes chromium at elevated temperatures but reduces FeO and, therefore, does not oxidize iron. Oxidation tests at 900°C in moist air on low chromium-iron alloys revealed that specimens which had been pretreated in this way at 1000°C for one or more hours, exhibited a 2- to 4-fold increase in oxidation resistance over untreated wires. Or, to express this differently, a 5 per cent Cr steel wire became equivalent in oxidation resistance to a 9 per cent Cr steel.

It was also found that certain salts applied to the surface of low-chromium iron wires affected the oxidation rates. Some salts were beneficial (e.g., NaCl) but most of them were damaging to oxidation life. Whether or not salt treatment is effective in increasing oxidation resistance appears to depend on composition of the alloy as well as the specific test atmosphere. Dr. Uhlig mentioned that more work will be necessary to classify chemical compounds into the categories of those that benefit and those that damage the protective nature of high-temperature oxides.

Professor H. J. Yearian of Purdue University discussed his research on the mechanism of high temperature oxidation resistance and the role of alloying elements in developing this resistance. Most of the work has been confined to the oxidation of chromium steels in pure oxygen and in air, with a limited amount being done on the atmospheric oxidation of nickel-chromium steels. In general, oxide formation has been followed by x-ray diffraction, electron diffraction, and electron microscope studies.

The oxide scales on a series of chromium steels, ranging from 5 to 26 per cent chromium content, formed by oxidation in pure dry oxygen or in air, have been identified by x-ray diffraction and electron diffraction techniques. A regular variation of the phases present, as a function of time and temperature, can be correlated with change in oxidation resistance. In contrast with pure iron, no FeO was found in the oxidation of iron-chromium alloys, indicating a possible function of chromium in producing an oxidation resitant material. The resistance to oxidation generally decreases as the chromium content of the alloy is diminished and as the temperature is increased. Oxidation resistance is apparently highest when films of Cr_2O_3 are formed, whereas the formation of Fe_3O_4 spinel type of oxides do not offer similar protection.

Since the protection afforded the metal by its oxide coating may not be due to the bulk-oxide acting as a mechanical barrier separating the reactants, but to some special properties of a relatively thin layer next to the metal, emphasis has also been placed on the study of the formation, structure, and properties of thin oxide films. Films have been stripped from the metal surface by electrolytic techniques using hydrogen saturated KCl or perchloric acid-acetic anhydride mixtures or by the more familiar bromine-methanol method. Electron diffraction studies of films formed on chromium steels indicate that no essential difference in oxide phases exists over the range of composition, temperature, and oxidation time. Both α Fe_2O_3-Cr_2O_3 and Fe_3O_4-$FeCr_2O_4$ oxide types are present in practically all cases. Electron micrographs of the stripped films provide an indication, however, of a dependence of the form of the oxide on alloy composition. The low chromium alloys give an oxide showing large crystalline masses in a matrix of small crystallites, while the higher Cr alloys grow more uniform films of small crystallites. Dr. Yearian believes, on the basis of his studies, that the variation in protectiveness of these thin oxide films, is not due principally to their composition, but to the degree of local imperfection that exists.

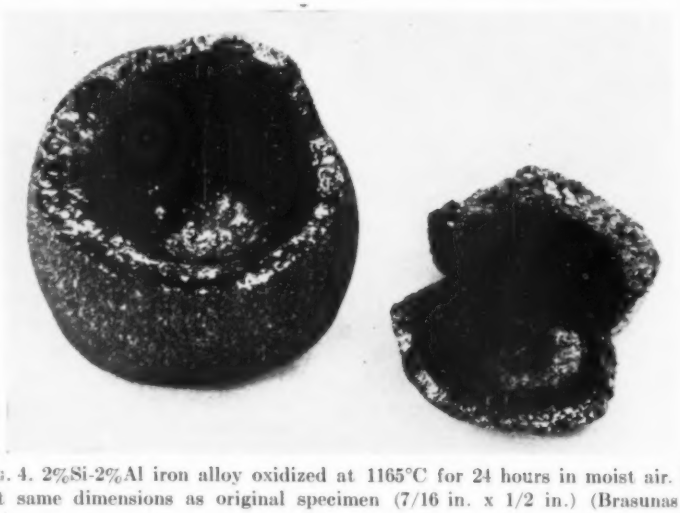


FIG. 4. 2%Si-2%Al iron alloy oxidized at 1165°C for 24 hours in moist air. Hole about same dimensions as original specimen (7/16 in. x 1/2 in.) (Brasunas and Uhlig).

Measurements of the electrical properties of the oxide scale and films are also under way, since these properties, as indicated by the theories of Mott and Wagner, are of importance in determining the rate of oxidation. Contact potential measurements reveal that the oxide has a higher work function than the metal.

* * *

It is planned to prepare a more detailed report of the Forum which will contain digests of the papers and the discussions. At such time as this report is available, a notice will be published in this JOURNAL.

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♣ ♣ ♣

An Electron Diffraction Study of the Structure of Zinc Oxide after Hydrogen Treatment

Ling Yang*

Recent observations of changes of the adsorption of gases on catalysts upon heating followed by cooling have received contradictory interpretations. H. S. Taylor and Shou-chu Liang (1, 2) account for their observations on H_2 on ZnO, in terms of desorption and readsorption at other active sites, and see therein a manifestation of the heterogeneity of the adsorbing surface. Beeck, Ritchie, and Wheeler (3) attribute what they term "slow adsorption" on Ni, to a sorption of gas into the lattice of the catalyst, and suggest that the same mechanism might be operative in Taylor and Liang's system H_2/ZnO. If that were the case, definite changes in lattice dimensions, crystal size, or orientation should be found in the temperature range of the anomalies of adsorption.

This was tested by the electron diffraction method on three types of ZnO: (1) a thin film of ZnO produced by atmospheric oxidation at 500°C on a bead of molten Zn, and outgassed at 400°C, showing essentially random orientation with only a faint (0001) orientation and very well resolved rings; (2) powder obtained by collecting the smoke of burning Zn, outgassed at 400°C, and showing completely random orientation, with crystals bigger than in 1, and very well resolved rings; and (3) a fully oriented monocrystalline film produced by 3 hours oxidation at 350°C of the (0001) plane of a Zn single crystal, reproducing completely the orientation of the base.

Each of the three specimens was evacuated 5 hours at 400°C and then treated with H_2 under 1 atm for 10 hours at 25°, 200°, and 280°C, i.e., in the temperature range in which Taylor and Liang observed the anomalies attributed to surface heterogeneity, then allowed to cool in H_2.

Absence of any structural or orientation change in sample (1) as a result of this treatment was ascertained by way of fitting the two halves of the suitably enlarged electron diffraction patterns of the original and the treated specimens. With the innermost *100* rings made to coincide, all other rings coincided very exactly, indicating that the c/a ratio has undergone no change, i.e., the lattice suffered no distortion. Sample (2) showed no change of the crystal size. On that same sample, absence of any change in the separate values of c and of a was established against graphite as standard, by means of a composite transmission pattern. Sample (3) showed neither a change of c/a nor any degree of disorientation.

In contrast to this total absence of structural, crystal size, or orientation changes at up to 280°C, heating of (3) in H_2 to 350°C did destroy part of the single-crystal structure. At that temperature, but at that temperature only, penetration of hydrogen into the lattice has taken place, and has manifested itself by a thorough reorientation.

It is therefore concluded that the electron diffraction method, although it is capable of revealing structural changes in ZnO in the temperature range where it does interact with H_2, fails to provide support for Beeck, *et al.'s* interpretation of Taylor and Liang's adsorption anomalies by intra-lattice sorption as an alternative to the idea of adsorptive surface heterogeneity.

Sorption into lattice defects, which would represent a considerable fraction of Beeck, *et al.'s* deep sorption if it occurred at all, should give rise to a broadening of diffraction rings, such as was actually found in x-ray diffraction lines of Fe charged electrolytically with hydrogen (4), and of electrolytic Ni[5], but not in ZnO treated with H_2. The amount of hydrogen involved in Beeck, *et al.'s* "slow adsorption" in Ni, being of the same order of magnitude as occluded in electrolytic Ni, ~1 cm^3(STP)/g Ni, it should, if it were sorbed into lattice defects of the metal, be detectable by electron or x-ray diffraction patterns.

Acknowledgment

I gratefully acknowledge the constant interest and help of Dean H. S. Taylor and of Dr. N. Thon. I am also indebted to Dr. Shou-chu Liang for stimulating discussions.

References

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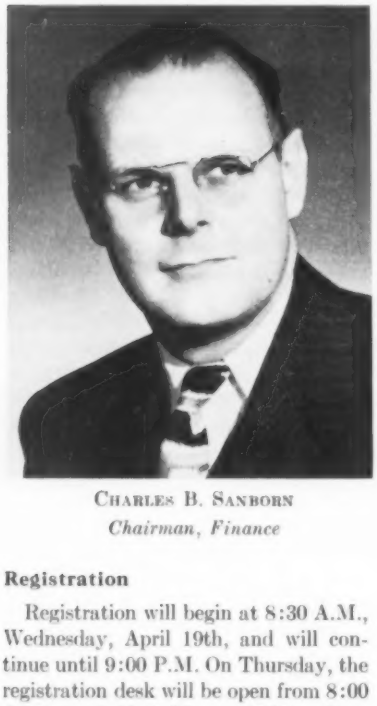
* Frick Chemical Laboratory, Princeton University. Princeton, New Jersey.

DISCUSSION OF TECHNICAL PAPERS

To appear in the semi-annual Discussion Section of the JOURNAL, written discussion of papers will be accepted up to two months following publication of a paper. Written discussion should be sent in duplicate to the Editor of the JOURNAL, 235 West 102 Street, New York, N. Y.

Cleveland Offers Largest Technical Program

The technical program for the Cleveland convention, to be held April 19th, 20th, 21st, and 22nd, at the Statler Hotel, will be the largest in the Society's history. Ninety papers have now been listed for the following symposia: Rare Metals, Electronics-Instrumentation, Industrial Electrolytic-Instrumentation, Electrothermics, Luminescence, Theoretical Electrochemistry, and Electric Insulation.



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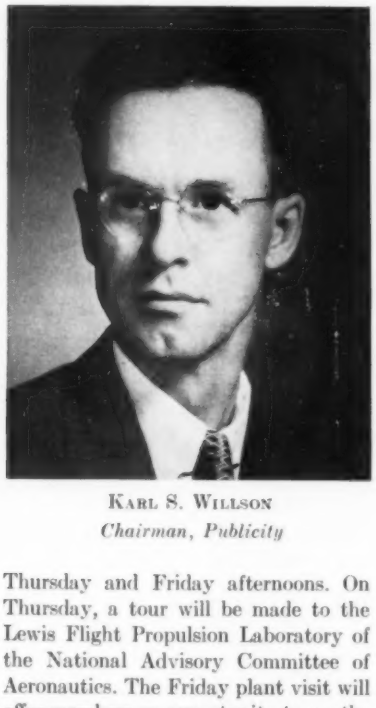

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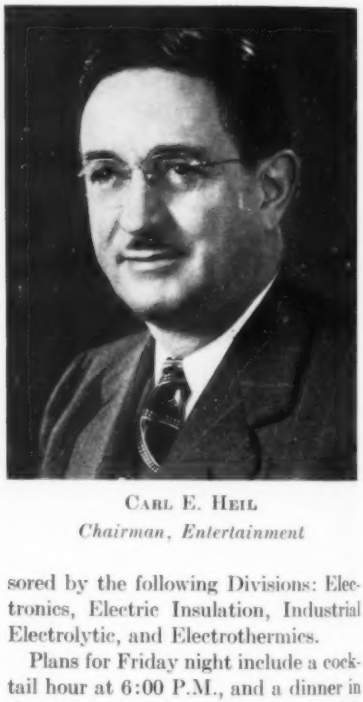


CARL E. HEIL
Chairman, Entertainment

Registration

Registration will begin at 8:30 A.M., Wednesday, April 19th, and will continue until 9:00 P.M. On Thursday, the registration desk will be open from 8:00 A.M. to 5:00 P.M., on Friday from 8:30 A.M. until 5:00 P.M., and on Saturday from 8:30 A.M. until 12:00 noon.

The registration fees for Wednesday, Thursday, or Friday are:

Members	$5.00
Ladies	$2.00
Students	$1.00
Nonmembers not included above	$7.00

The registration fee for Saturday morning only will be $1.00.

Members and nonmembers may obtain advance registration tickets costing $5.00 from Mr. L. E. Pucher, The Willard Storage Battery Company, 246 East 131st Street, Cleveland 1, Ohio.

Plant Trips

Plant trips of unusual interest to electrochemists have been arranged for Thursday and Friday afternoons. On Thursday, a tour will be made to the Lewis Flight Propulsion Laboratory of the National Advisory Committee of Aeronautics. The Friday plant visit will offer members an opportunity to see the B. F. Goodrich Research Center.

Luncheons and Dinners

A luncheon will be held at 12:30 P.M. in the Euclid Ballroom of the Statler Hotel. The Annual Business Meeting of the Society has been scheduled for this time, and all members are urged to attend.

Thursday night at 6:00 P.M., a reception will be held in the Pine Room for President and Mrs. Ferguson. Mr. W. G. Harvey will act as toastmaster at the Annual Banquet, which will be held at 7:30 P.M. in the Euclid Ballroom. Following the dinner, award will be made of the Young Author's Prize and the Turner Book Prize, and the Presidential Address will be delivered by Dr. Ferguson.

Luncheons on Friday will be sponsored by the following Divisions: Electronics, Electric Insulation, Industrial Electrolytic, and Electrothermics.

Plans for Friday night include a cocktail hour at 6:00 P.M., and a dinner in the Statler Ballroom at 7:15 P.M. Immediately following the dinner will be informal entertainment provided by the Local Committee. A well-known orchestra will provide music for dancing.

Ladies' Program

The ladies attending the convention will be assured a full and interesting program. They will tour the west side of Cleveland and its suburbs on Thursday

morning, and will have a luncheon in the beautiful Seaglade room of the Lake Shore Hotel, overlooking Lake Erie. After lunch, Miss Elizabeth Kardos, Director of the Kardos Fashion Institute of Cleveland, will provide a program devoted to the subject of "Packaging Your Personality."

On Friday, the ladies will tour the east side of Cleveland and its suburbs, and will be entertained at a complimentary luncheon at one of the local country clubs.

Technical Program

Rare Metals

Wednesday, April 19, 1950

Titanium, Zirconium, and Palladium

10:15 A.M.—Opening of the session, with welcome by Chairman Gonser

10:20 A.M.—Keynote Address, "The Less Important Metals and the Future," by B. S. Hopkins

10:40 A.M.—"Beneficiation of High Titanium Indian Bauxite through Chlorination" by Colin G. Fink and K. G. Hrishikesan, Columbia University, New York, N. Y.

11:05 A.M.—"The Formation of Refractory Coatings by Vapor-Deposition Methods. II. The Deposition of Group IV Metals" by C. F. Powell, I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio, and C. C. Heim, Kaiser Aluminum and Chemical Corporation, Spokane, Wash.

11:30 A.M.—"Heat Resistance of Zirconium in Several Media" by E. T. Hayes, A. H. Roberson, and R. H. Robertson, U. S. Bureau of Mines, Albany, Ore.

11:55 A.M.—"Improvements in the Methods for the Reduction of Zirconium Chloride with Magnesium" by W. J. Kroll, W. F. Hergert, and L. A. Yerkes, U. S. Bureau of Mines, Albany, Ore.

12:20 P.M.—"Palladium Plating Baths for Heavy Deposits and Electroforming" by E. M. Wise and R. F. Vines, International Nickel Company, New York, N. Y.

Gallium, Germanium, Selenium, and Thallium

2:00 P.M.—"The Electrochemistry of Gallium" by William M. Saltman and Norman H. Nachtrieb, Institute for the Study of Metals, The University of Chicago, Chicago, Ill.

2:30 P.M.—"Evaluation of Quality of Germanium by Electrical Methods" by W. C. Dunlap, Jr., Research Laboratory, General Electric Company, Schenectady, N. Y.

3:00 P.M.—"Single Crystals of Germanium and Investigation of Single Grain Boundaries" by W. E. Taylor, H. Y. Fan, and K. Lark-Horovitz, Department of Physics, Purdue University, Lafayette, Ind.

3:30 P.M.—"Counterelectrodes for Selenium Rectifiers" by Wm. B. Roberts, Sylvania Electric Products Inc., Bayside, L. I., N. Y.

4:00 P.M.—"The Formation of Refractory Coatings by Vapor-Deposition Methods. IV. The Deposition of Chromium, Molybdenum, Tungsten, Uranium, Rhenium, and the Platinum Group Metals. The Deposition and Formation of Alloy Coatings" by D. L. Day, C. F. Powell, I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio, and C. C. Heim, Kaiser Aluminum and Chemical Corporation, Spokane, Wash.

R. A. Schaefer
Chairman, Cleveland Section

4:30 P.M.—"Ductile Chromium" by W. J. Kroll, W. F. Hergert, and L. A. Yerkes, U. S. Bureau of Mines, Albany, Ore.

5:00 P.M.—"The Properties and Uses of Thallium" by H. E. Howe and A. A. Smith, Jr., Research Department, American Smelting and Refining Company, Barber, N. J.

Thursday, April 20, 1950

Note: The Rare Metals Division has scheduled no session for Thursday morning, so that members and guests may attend the Electrothermics Symposium.

Vanadium and Beryllium

2:00 P.M.—"A Review of the System Vanadium-Oxygen" by N. P. Allen, National Physical Laboratory, Teddington, Middlesex, England

2:30 P.M.—"The Formation of Refractory Coatings by Vapor-Deposition Methods. III. The Deposition of Vanadium, Tantalum, and Columbium" by L. C. Beale, Jr., C. F. Powell, and I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio

3:00 P.M.—"Production of Ductile Vanadium by Calcium Reduction of Vanadium Trioxide" by E. D. Gregory, Research Department, Westinghouse Electric Corporation, Bloomfield, N. J.

3:30 P.M.—"Preparation of Ductile Vanadium by Calcium Reduction" by R. K. McKechnie and A. U. Seybolt, General Electric Company, Schenectady, N. Y.

4:00 P.M.—"A Preliminary Study of the Reactions of Vanadium with O_2 and N_2" by Earl A. Gulbransen and Kenneth F. Andrew, Westinghouse Research Laboratories, East Pittsburgh, Pa.

4:30 P.M.—"Equilibria in the Decomposition of Beryllium Iodide at Elevated Temperatures" by Bernard Kopelman and Harry Bender, Sylvania Electric Products Inc., Bayside, L. I., N. Y.

5:00 P.M.—"Kinetics of the Reactions of Beryllium with O_2, N_2 and H_2, and the Effects of Oxide and Nitride Films on Its Vapor Pressure" by Earl A. Gulbransen and Kenneth F. Andrew, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Electronics Instrumentation

Wednesday, April 19, 1950

10:15 A.M.—"Selection of Talc for Industrial Uses by X-Ray Diffraction" by G. L. McCreery, The Ohio Brass Company, Barberton, Ohio

10:45 A.M.—"High Temperature and Controlled Atmosphere X-Ray Diffraction Techniques" by J. J. Lander, Bell Telephone Laboratories, Murray Hill, N. J.

11:15 A.M.—"The Applicability of Ultrasonics to Continuous Gas Analysis" by J. C. Hubbard, The Catholic University of America, Washington, D. C.

11:45 A.M.—"Selective Infrared Gas Analysis" by Wm. G. Fastie, Leeds & Northrup Company, Philadelphia, Pa.

12:15 P.M.—"Ultraviolet Methods of

Continuous Gas Analysis" by L. G. Glasser, Engineering Research Laboratory, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.

2:00 P.M.—"A Cathode-Ray Recording Apparatus for Polarization Studies" by A. L. Ferguson, University of Michigan, Ann Arbor, Mich., and D. R. Turner, Westinghouse Research Laboratories, East Pittsburgh, Pa.

2:30 P.M.—"Electronic Instrumentation for Overvoltage Measurements" by Dimitrios Staicopoulos, Ernest Yeager, and Frank Hovorka, Departments of Chemistry and Physics, Western Reserve University, Cleveland, Ohio

3:00 P.M.—"Application of Electrolytic Conductivity of Gas Analyses" by Moyer D. Thomas and James O. Ivie, Department of Agricultural Research, American Smelting and Refining Company, Salt Lake City, Utah

Instrumentation in the Chlor-Alkali Industry

Wednesday, April 19, 1950

3:30 P.M.—"Instrumentation in a Modern Chlorine Handling Plant" by J. M. Hildyard, Hooker Electrochemical Company, Niagara Falls, N. Y.

4:00 P.M.—"Liquid Chlorine Level Measurement" by F. S. McCarthy and G. A. Rice, Chemicals Department, Canadian Industries Limited, Montreal, Canada

Thursday, April 20, 1950

9:00 A.M.—"A Flow Colorimeter Adapted to Chlorine Analysis" by R. C. Hawes, R. R. Davis, A. O. Beckman, National Technical Laboratories, South Pasadena, Calif., and H. H. Cary, Applied Physics Corporation, Pasadena, Calif.

9:30 A.M.—"Detection of Hydrogen in Chlorine" by Russell E. Cushing, Instrument Process Control Division, Pennsylvania Salt Manufacturing Company, Philadelphia, Pa.

10:00 A.M.—"The Voltage Balance in the Mercury Cell" by Vittorio de Nora, Impianti Elettrochimici, Milan, Italy

10:30 A.M.—"Automatic Control Applied to 'Karbate' Falling Film Hydrogen Chloride Absorbers" by W. M. Gaylord, National Carbon Division, Union Carbide and Carbon Corporation, Niagara Falls, N. Y.

11:00 A.M.—"Salt Slurry Control in Caustic Evaporators" by Albert W. Eckstrom, "Buflovak" Equipment Division, Blaw-Knox Company, Buffalo, N. Y.

11:30 A.M.—"Control of Bleach Manufacture by Oxidation Potential" by D. J. Pye, Great Western Division, The Dow Chemical Company, Pittsburgh, Calif.

Electrothermics

Wednesday, April 19, 1950

Note: The Electrothermics Division has scheduled no session on the new highly refractory materials for Wednesday morning, to permit members and guests to attend the Rare Metals Symposium.

Borides, Nitrides, and Phase Studies

2:00 P.M.—"The Metallic Nature of Metal Borides" by S. J. Sindeband and Paul Schwarzkopf, American Electro Metal Corporation, Yonkers, N. Y.

2:30 P.M.—"The Borides of Some Transition Elements" by Roland Kiessling, Institute of Chemistry, University of Uppsala, Uppsala, Sweden

3:00 P.M.—"Phase Relationships in the Binary Systems of Nitrides and Carbides of Zirconium, Columbium, Titanium, and Vanadium" by Pol Duwez and Francis Odell, Department of Mechanical Engineering, California Institute of Technology, Pasadena, Calif.

3:30 P.M.—"Electrothermal Preparation of Pure Crystalline Boron, Boron Nitride, and Boron Carbide, and Their Characteristics" by Eugene Ryshkewitch, 43 Drake Avenue, Dayton, Ohio

4:00 P.M.—"The Formation of Refractory Coatings by Vapor-Deposition Methods. VI. The Refractory Nitrides, Borides, Silicides, and Oxides" by C. F. Powell, D. H. Nowicki, and I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio

Thursday, April 20, 1950

High-Temperature Operations

9:00 A.M.—"Some Aspects of the Use of Solar Energy for Studying Highly Refractory Compounds and Materials" by William M. Conn, Physics Department, Rockhurst College, Kansas City, Mo.

9:30 A.M.—"Refractories for Four Thousand Degrees Plus" by Gordon R. Finlay, Norton Company Research Labs., Chippawa, Ontario, Canada

10:00 A.M.—"Usefulness of Pure Oxide Refractories in Protecting and Insulating High Temperature Thermocouples" by Gary Steven, Armour Research Foundation, Chicago, Ill.

10:30 A.M.—"The Protection of Molybdenum from Oxidation in Air at High Temperatures" by C. F. Powell, E. A. Beidler, I. E. Campbell, B. W. Gonser, Battelle Memorial Institute, Columbus, Ohio, and L. F. Yntema, Fansteel Metallurgical Corporation, North Chicago, Ill.

11:00 A.M.—"Heat Resistant Protective Coatings" by R. A. Williams, I. H. Lutz, and W. H. Hayne, University of Louisville Institute of Industrial Research, Louisville, Ky.

11:30 A.M.—"Refining of Magnesium by Vaporization at Extremely Low Pressure" by R. R. Rogers and G. E. Viens, Division of Mineral Dressing and Process Metallurgy, Department of Mines and Technical Surveys, Ottawa, Canada.

New Highly Refractory Carbides

2:00 P.M.—"Effect of Chromium on the Oxidation Resistance of Titanium Carbide" by John D. Roach, Titanium Alloy Manufacturing Division, National Lead Company, Niagara Falls, N. Y.

2:30 P.M.—"The Formation of Refractory Coatings by the Vapor-Deposition Method. V. The Refractory Carbides" by C. F. Powell and I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio.

3:00 P.M.—"Preparation of Alumina-Titanium Carbide Bodies by Hot Pressing" by Harold Barr, George D. Cremer, and Walter J. Koshuba, NEPA Division, Fairchild Engine and Airplane Corporation, Oak Ridge, Tenn.

3:30 P.M.—"Refractories for Highly Corrosive Fluorosilicate Melts" by W. Eitel, R. A. Hatch, and R. A. Humphrey, U. S. Bureau of Mines, Norris, Tenn.

4:00 P.M.—" 'Durhy'—An Unusual Silicon Carbide Body" by C. G. Rose, Research Department, The Carborundum Company, Niagara Falls, N. Y.

Friday, April 21, 1950

New Highly Refractory Oxides

9:00 A.M.—"Production of Fused Stabilized Zirconia" by D. W. Marshall, Norton Company Research Laboratories, Chippawa, Ontario, Canada

9:30 A.M.—"Stabilized Zirconia Refractories" by O. J. Whittemore, Jr.,

Norton Company Research Laboratories, Worcester, Mass.

10:00 A.M.—"Vapor Pressure of Beryllium Oxide" by N. D. Erway, 155 Lincoln Street, Oregon, Wis., and R. L. Seifert, Indiana University, Bloomington, Ind.

10:30 A.M.—"Sintered Oxides" by Karl Schwartzwalder and Helen B. Barlett, AC Spark Plug Division, General Motors Corporation, Flint, Mich.

11:00 A.M.—"High Temperature Electrical Insulators" by W. T. Rawles, Chemicals Division, General Electric Company, Pittsfield, Mass.

11:30 A.M.—"High-Temperature Bodies in the System MgO-TiN-NiO" by L. D. Hower, Jr., H. F. G. Ueltz, and J. W. Londeree, Jr., Rutgers University, New Jersey Ceramic Research Station, New Brunswick, N. J.

Cermets and Metal-Ceramic Systems

2:00 P.M.—"A Survey of High Temperature Metals and Ceramics" by Hans Thurnauer, American Lava Corporation, Chattanooga, Tenn.

2:30 P.M.—"Metal Ceramics for High Temperature Applications" by W. O. Sweeny, Haynes Stellite Division, Union Carbide and Carbon Corporation, Kokomo, Ind.

3:00 P.M.—"A Study of High Temperature Oxidation Kinetics in Metal Oxide Mixtures" by V. D. Frechette, W. B. Crandall, H. S. Levine, and G. E. Lorey, New York State College of Ceramics at Alfred University, Alfred, N. Y.

3:30 P.M.—"Hydrostatic Pressing as a Fabrication Technique" by H. E. Wagner and C. G. Harman, Battelle Memorial Institute, Columbus, Ohio

4:00 P.M.—"Fundamental Concept in Sintering and Properties of Oxide-Metal Cermets" by T. S. Shevlin, Engineering Experiment Station, Ohio State University, Columbus, Ohio.

4:30 P.M.—"Soldering of Ceramics and Nonmetals" by R. J. Bondley, General Electric Company, Schenectady, N. Y.

Saturday, April 22, 1950

Round Table on the New Highly Refractory Materials

9:00 A.M.–12:00 M.—An informal "off the record" discussion of papers presented at the Electrothermics Sessions will be led by prominent authorities in the field. All those interested are invited to attend and participate in the discussions.

Luminescence

Thursday, April 20, 1950

9:05 A.M.—Invited Keynote Address, "The Ideal Phosphor," by Professor Roland Ward

9:35 A.M.—"Effect of Thermal History on Color of Zinc Beryllium Silicate (Mn) Phosphors" by Shannon Jones, Lamp Department, General Electric Company, Cleveland, Ohio

9:50 A.M.—"Calcium Antimonates" by Keith H. Butler, Martha J. Bergin, and Virginia M. B. Hannaford, Sylvania Electric Products Inc., Salem, Mass., and Bayside, L. I., N. Y.

10:20 A.M.—"Spiraling in Fluorescent Lamps" by R. van Male de Ghorain and André Luyckx, Université de Louvain, Louvain, Belgium

10:50 A.M.—"A Study of the Mechanism of Sensitized Luminescence of Solids" by James H. Schulman, Robert J. Ginther, and Clifford C. Klick, Crystal Branch, Naval Research Laboratory, Washington, D. C.

11:35 A.M.—"The Origin of Multiple Bands in Luminophors Activated by Divalent Manganese" by F. A. Kroeger and P. Zalm, Philips Research Laboratories, Eindhoven, Netherlands

11:55 A.M.—"The Fluorescence of Magnesium Germanate Activated by Manganese" by F. A. Kroeger and J. van den Boomgaard, Philips Research Laboratories, Eindhoven, Netherlands

2:00 P.M.—"Barium Magnesium Silicate Phosphors" by Keith H. Butler and James G. Cassanos, Sylvania Electric Products Inc., Salem, Mass.

2:30 P.M.—"Some Interesting Rare Earth Activated Phosphors" by H. G. Jenkins and A. H. McKeag, Research Laboratories, The General Electric Company, Limited, Wembley, England

2:50 P.M.—"Calcium Halophosphate Phosphors. I. Analysis of Emission Spectra" by Keith H. Butler and Charles W. Jerome, Sylvania Electric Products Inc., Salem, Mass.

3:10 P.M.—"Luminescence Emission of Manganese-activated Zinc Silicate at Liquid Helium Temperature" by Clifford C. Klick and James H. Schulman, Crystal Branch, Naval Research Laboratory, Washington, D. C.

3:30 P.M.—"The Zinc Silicate Phosphors Fluorescing in the Yellow and Red" by H. G. Pfeiffer and Gorton R. Fonda, Research Laboratory, General Electric Company, Schenectady, N. Y.

4:00 P.M.–5:00 P.M.—The Luminescence group has scheduled a Round Table for this time so that those attending the session may have an

AIRPLANE VIEW OF A PORTION OF UNIVERSITY CIRCLE. IN LEFT FOREGROUND IS SEVERANCE HALL, HOME OF THE CLEVELAND SYMPHONY ORCHESTRA. GROUP OF BUILDINGS IN CENTER OF PICTURE INCLUDES UNIVERSITY HOSPITALS AND SCHOOL OF MEDICINE OF WESTERN RESERVE UNIVERSITY. PARTIALLY HIDDEN BY TREES IN FOREGROUND ARE OTHER BUILDINGS OF VARIOUS COLLEGES OF WESTERN RESERVE UNIVERSITY. CAMPUS AND BUILDINGS OF CASE INSTITUTE OF TECHNOLOGY APPEAR IN THE RIGHT FOREGROUND.

opportunity for an informal and more detailed discussion of the papers presented at this meeting.

Electric Insulation

Friday, April 21, 1950

New Techniques in Electrical Insulation Research

3:15 P.M.—"The Breakdown of Electrical Insulation at Radio Frequencies" by John J. Chapman, Johns Hopkins Research Institute, Baltimore, Md.

4:00 P.M.—"The Infrared Analysis of Polyvinyl Formal" by Harold C. Beachell, University of Delaware, Newark, Del.

4:45 P.M.—"The Thermal Evaluation of Polyvinyl Formal" by Thomas D. Callinan, Naval Research Laboratory, Washington, D. C.

Saturday, April 22, 1950

Paper-Makers' Contributions to Electrochemical Arts

9:00 A.M.—"The Manufacture of Electrical Insulating Paper" by Phillip L. Staats, General Electric Company, Pittsfield, Mass.

10:00 A.M.—"Manufacture and Properties of Asbestos Paper" by Robert G. Quinn, Johns-Manville Research Center, Finderne, N. J.

11:00 A.M.—"The Manufacture and Properties of Integrated Mica" by Moses D. Heyman, Integrated Mica Corporation, Woodmere, N. Y.

Theoretical Electrochemistry

Friday, April 21, 1950

9:00 A.M.—"Electrodeposition Behavior of a Simple Ion. II. Precipitation into a Liquid Electrode (mercury)" by L. B. Rogers, Massachusetts Institute of Technology, Cambridge, Mass.

9:30 A.M.—"Electrodeposition Behavior of a Simple Ion. III. Applications of Coprecipitation Phenomena" by L. B. Rogers and John T. Byrne, Massachusetts Institute of Technology, Cambridge, Mass.

10:00 A.M.—"Anodic and Cathodic Depolarization Effects on Various Metals in Sulfuric Acid Solutions" by A. L. Ferguson, University of Michigan, Ann Arbor, Mich., and D. R. Turner, Westinghouse Research Laboratories, East Pittsburgh, Pa.

10:30 A.M.—"Anode Effect in Aqueous Electrolysis" by H. H. Kellogg, School of Mines, Columbia University, New York, N. Y.

11:00 A.M.—"Gold-plated Electrode for Measuring Conductance of Electrolytes" by Sidney Barnartt, Westinghouse Research Laboratories, East Pittsburgh, Pa.

11:30 A.M.—"On the Determination of the Roughness of Metallic Surfaces" by Carl Wagner, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

12:00 M.—"Nitric Acid—Nitrous Acid Concentration Cells" by William Cabler Moore, Consulting Chemist, Stamford, Conn.

2:00 P.M.—"The Effect of Acoustical Radiations on the Hydrogen Electrode" by Ernest Yeager and Frank Hovorka, Department of Chemistry, Western Reserve University, Cleveland, Ohio.

2:25 P.M.—"Hydrogen Overvoltage of Titanium and Zirconium" by Carl G. Moore, D. S. McKinney, and J. C. Warner, Department of Chemistry, Carnegie Institute of Technology, Pittsburgh, Pa.

2:50 P.M.—"On the Theory of Corrosion of Composite Electrodeposited Coatings" by J. E. Stareck, United Chromium Inc., Detroit, Mich.

NACE to Meet in St. Louis, April 4–7

The National Association of Corrosion Engineers will hold their annual meeting at the Jefferson Hotel in St. Louis on April 4–7. The schedule of symposia to be presented is as follows:

1. Corrosion Principles Symposium—Afternoon, April 4
2. Chemical Industry Symposium—Morning, April 5
3. Cathodic Protection Symposium—Morning, April 5
4. Oil and Gas Industry Symposium—Afternoon, April 5
5. Transportation Industry Symposium—Afternoon, April 5
6. Protective Coatings Symposium—Morning, April 6
7. Fresh and Salt Water Corrosion Symposium—Morning, April 6
8. Food Industry Symposium—Afternoon, April 6
9. Pipe Line Corrosion Symposium—Afternoon, April 6
10. Pipe Line Protection Round Table—Morning, April 7
11. General Corrosion Problems Round Table—Morning, April 7

A tentative program issued by the Headquarters office of the Society in Houston, lists the following Electrochemical Society members on the program: R. H. Brown, Research Laboratories, Aluminum Company of America; G. C. English, Research Laboratories, Aluminum Company of America; N. Hackerman, University of Texas; R. B. Hoxeng, Case Institute of Technology; F. L. LaQue, The International Nickel Company, Inc.; Oliver Osborn, The Dow Chemical Company; C. F. Pogacar, Koppers Company; H. A. Robinson, The Dow Chemical Company; F. N. Speller, Consultant; E. A. Tice, The International Nickel Company, Inc.; and H. H. Uhlig, Massachusetts Institute of Technology.

Monsanto Has New Company in India

Monsanto Chemicals of India Limited is the name of a new company whose formation was recently announced by the president of Monsanto Chemical Company in St. Louis.

The new company is jointly owned by the American company and its British subsidiary, Monsanto Chemicals Limited. Its headquarters will be in Bombay, India, and it will handle Monsanto activities in India. Present plans include the establishment of a selling organization in India and it is expected that later the company will manufacture products there to meet local demands.

$5,000,000 Ammonia Plant for Dow

The Dow Chemical Company has announced that their new $5,000,000 ammonia plant at Freeport, Texas, is now under construction. The company expects the plant to be completed and in production by late 1950.

The new plant will produce refrigeration grade and technical grade anhydrous ammonia in tank-car quantities as well as quantities of aqua ammonia for industrial and agricultural consumers in the South and Mississippi Valley. Anhydrous ammonia is an important source of nitrogen for use in fertilizers.

In the industrial field ammonia is used in the manufacture of chemicals, plastics, synthetic fibers, oil, steel, naval stores, and as a refrigerant.

Firm Name Changed

The name of the Waterbury Battery Company, Waterbury, Connecticut, has been changed to Schoenmehl Battery Company, according to information received from M. L. Martus, president and treasurer of the company.

DIVISION NEWS

Electronics Division

For several years, a committee headed by Dr. J. W. Marden has been engaged in revising the by-laws of the Electronics Division. The revision was necessary because of the broadened scope of the Division's activities and some changes in the constitution of the Society. The revised by-laws of the Division were submitted to the Board of Directors of the Society at their meeting on December 3, 1949, and were approved as submitted.

The Electronics Division has sponsored symposia and round tables on Luminescence and Fluorescence, Rare Metals, Electronic Instrumentation, and related subjects as well as General Electronics. Because of this diversity of interests within the Division, the new by-laws call for the election of several vice-chairmen, each of whom will represent one of the above subjects in the Division.

The annual business meeting of the Electronics Division will be held at the Spring Convention at Cleveland; details will be given as soon as the final arrangements are completed. At this meeting, the new by-laws will be presented to the membership for their approval; election of officers is also on the agenda.

Copies of these by-laws are being sent to all known members of the Electronics Division. However, with the rapidly expanding program of this Division, it has not been possible to keep up with all persons interested in the subjects outlined above. If you do not receive a copy of the by-laws and are interested in any phase of the fields of activity of the Electronics Division, please notify the secretary of the Division:

J. R. Musgrave
The Eagle-Picher Company
P. O. Box 290
Joplin, Missouri

Your name can then be added to the membership list of the Electronics Division.

The nominating committee consisting of Dr. J. W. Marden, Chairman, E. Gideon Widell, and Dr. Marlin E. Fogle have proposed the following nominations:

General Chairman — Erwin Lowry, Sylvania Electric Products, Inc.

Vice-Chairman for Fluorescent Group —Herman Froelich, General Electric Company

Vice-Chairman for Rare Metals Group —Bruce Gonser, Battelle Memorial Institute

Vice-Chairman for General Electronics Group—D. W. Wamsley, R.C.A. Manufacturing Co.

Secretary-Treasurer for Electronics Division—John R. Musgrave, Eagle-Picher Company.

The by-laws state: Article IV, Sections 2a and 2d—

"Additional nominations for offices may be made by petition signed by five (5) members of the Division which must be in the hands of the Chairman of the nominating committee before the election."

"Each nominee should be notified in advance of the responsibility of the office, and the nominating committee should receive his assurance of willingness to serve if elected."

John R. Musgrave
Secretary-Treasurer

Electrothermic Division

The nominations listed below for the annual election of officers for the Electrothermic Division will be voted on at the Cleveland Convention:

Chairman: Julian Glasser, Armour Research Foundation, Chicago. Illinois

Vice-Chairman: C. H. Chappell, National Carbon Company, Niagara Falls, New York

Secretary-Treasurer: I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio

SECTION NEWS

Chicago Section

About 40 members and guests attended the February 3rd meeting of the Chicago Section, held at the Chicago Engineers' Club. Following the social hour, an excellent steak dinner was enjoyed. During the short business meeting which followed, the new Section by-laws, revised to meet the Society's policy, were read and formally adopted.

Dr. J. Howard Brown, Assistant Director of Research, Oldbury Electro-Chemical Company, Niagara Falls, New York, was the guest speaker for the occasion. He delivered a most informative and interesting lecture on "The Less Common Acids of Phosphorus" in which he discussed the many acids of phosphorus and their related compounds, a work in which he has been a vigorous leader for some time. Dr. Brown developed the chemistry by the organic approach to the structure of these compounds and then proceeded to show some of their possible uses. In the development of the various acids of phosphorous it was shown that several of them could be shipped in a dry form if moisture was excluded from them during transit. Of the several new uses having commercial potential, he said that of sodium hypophosphite in the Bureau of Standards' method of chemical plating of nickel and cobalt has the greatest significance to the electroplating industry.

Dr. Brown has been a vigorous leader in the work of mapping the properties of the many acids and compounds of phosphorus by the Oldbury Electro-Chemical Company.

J. H. Conolly, *Secretary*

Cleveland Section

The Cleveland Section, at its meeting at the Cleveland Engineering Society on February 14th, continued its work on plans for the Society's spring convention in that city.

Following the business meeting, Professor George Glockler of the State University of Iowa addressed the Section on "Chemical Effects Produced by Free Electrical Particles." In this talk the various modes of causing reactions of chemical systems were reviewed. Dr. Glockler pointed out that increase of temperature leads to increase in reaction rate, because more molecules of high energy content exist at a higher temperature. Other methods of activation were discussed, such as photochemistry where radiation is brought into the chemical system so that, by absorption, activated molecules are produced.

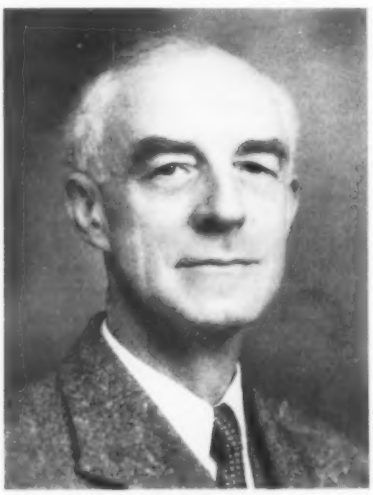
The speaker stated that whenever ionization is produced in a system, ions, electrons, and radiation will be present and consequently chemical reactions are induced as, for example, by means of the alpha particles of radon or in the various forms of electrical discharge. A study of the later reactions leads to a mode of activation by means of electrons of known speed. It is expected that this last mentioned type of activation will help to elucidate the behavior of chemical systems in electrical discharge. These problems, said Dr. Glockler, assume greater importance now than ever before since atomic explosions are accompanied by the production of radiations of various types. Their influence on biological systems is of great significance to all of us.

H. C. Froelich, *Secretary*

Niagara Falls Section

The Niagara Falls Section heard an interesting lecture by Dr. S. R. Scholes, Head of the Department of Glass Technology, New York State College of Ceramics at Alfred University, Alfred, New York, at its February 8th meeting at the Red Coach Inn.

Dr. Scholes discussed "Ceramics at High Temperatures," a topic in which he is widely experienced. After receiving his Ph.D. degree, Dr. Scholes was appointed to the Fry Glass Company Fellowship at the University of Pittsburgh, and at the end of that term he became chemist for the Fry Glass Company. He was later connected with the Mellon Institute. During these years he made many experiments and developments in glass making. He continued his work in this field, chiefly in industrial plants, until 1932 when he came to Alfred University.



S. R. SCHOLES

In his talk, Dr. Scholes discussed the behavior of ceramic bodies and materials at high temperatures, with reference to phase-equilibrium studies. The effects of reaction, liquid formation, and crystal growth or its absence, were treated as they apply to the firing of ware, the melting of glass, and the utility of refractories. The limitations of ceramic bodies as refractories for extreme applications such as rockets and jet engines were also briefly treated. The speaker stated that although ceramic manufacture always involves relatively high temperatures, attention is called to the fact that other processes, for example ferrous metallurgy, require higher temperatures than processes in ceramics.

M. S. KIRCHER, *Secretary-Treasurer*

PERSONALS

CONSTANTIN FRENKEL is now associated with John Miles & Partners, Ltd, 76 Cannon Street, London, England. Mr. Frenkel was previously connected with H. A. Brassert & Co. Ltd., in London.

WILLIAM E. C. EUSTIS is now with the W. S. MacDonald Company, Inc., of Cambridge, Massachusetts. Mr. Eustis was formerly connected with the Metals Research Laboratory, Burlington, Vermont.

ERNEST RAMIREZ has joined the staff of the Testing and Research Laboratories, General American Transportation Corporation, in East Chicago, Indiana. Mr. Ramirez had been at the Graduate School of Illinois Institute of Technology, Chicago, Illinois.

FRANK N. SPELLER, "Dean" of corrosion engineers, met with an accident while inspecting corroded diesel engines, and broke his leg in two places, suffered a split knee-cap, broken thumb, and bruises. Dr. Speller is convalescing at Mercy Hospital, Stevenson & Locust Streets, Pittsburgh, Pennsylvania.

Dr. Francis Frary Honored by AIME

Dr. Francis C. Frary, Director of Research, Aluminum Company of America, was awarded the James Douglas Metallurgical Medal for 1950 by the American Institute of Mining and Metalurgical Engineers at their annual banquet, held February 15th, in the Hotel Statler, New York City. Dr. Frary received the award "for distinguished achievement in science and contribution to society by broadening the field of knowledge in all phases of the aluminum industry and for his notable success in directing a vast research project in this industry." The medal has been awarded only four times in the past ten years.

The medalist has had a long career of outstanding accomplishments, two of the more important being the production for the first time of very pure aluminum (99.99%) by electrolytic refining, and the production of pure alumina by electrothermal processes. He holds some thirty United States patents and is the author and co-author of numerous books and papers in the fields of metallurgical and chemical research.

In addition to this high honor from AIME, Dr. Frary has previously received an impressive list of medals. Included in these are the Gold Medal of the American Society for Metals, the Perkin Medal of the Society of Chemical Industry, the Acheson Gold Medal and Prize of The Electrochemical Society, and the Pittsburgh Award of the American Chemical Society, Pittsburgh Section.

Dr. Frary has been Director of Research of the Aluminum Company of America since 1918, when he started with a small staff, and has since guided the Research Laboratories to their present position of international prominence. He is a member of a number of important scientific societies including The Electrochemical Society of which he is a past president.

Dr. Herndon Directs Research at Mathieson

L. Kermit Herndon, Professor of Chemical Engineering at Ohio State University, has been named Director of Research for Mathieson Chemical Corporation, according to a recent announcement by Vice-President C. F. Prutton, director of operations.

L. K. HERNDON

Dr. Herndon's duties will include heading research, pilot plant, and market development work, with headquarters at the company laboratories in Niagara Falls, New York, and an office in the Mathieson Building in Baltimore.

Prior to his present appointment, Dr. Herndon was consulting engineer to the company, and will continue in his university post while completing graduate research assignments and supervising Mathieson's Ohio State University Research Foundation project.

BOOK REVIEWS

METAL CLEANING: BIBLIOGRAPHICAL ABSTRACTS prepared by Jay C. Harris (Special Technical Publication No. 90). Published by the American Society for Testing Materials, Philadelphia, Pa., 1949. 68 pages, $2.75; to A.S.T.M. members, $2.00.

This is a convenient manual of 494 abstracted references on metal cleaning, including patents. The articles are arranged first by year, and then by author or, where anonymous, by journal. The first reference is for 1893, following which there is an inexplicable gap to 1922. Where possible the original articles have been abstracted; otherwise "many . . . are re-abstracts from journals such as *Chemical Abstracts* or *Journal of the Institute of Metals*, i.e., *Metallurgical Abstracts*." There are very complete author, subject, and patent indices. The publication is expected to be "amplified at more or less regular intervals."

The work is not intended to be exhaustive. In its present form, it is a convenient and ready reference-manual on the subject and will in many instances prove more practical and useful than a more exhaustive work. A serious omission, however, would seem to be that of the review articles by Nathanial Hall and George B. Hogaboom, Jr., on "Technical Developments" for the years 1940–1945, in the first issues of *Metal Finishing* for the years 1941–1946. While these articles cover more subject matter than cleaning, they still have many references on the subject, including many patents, not listed in this bibliography. In general, however, the work is a welcome addition for quick reference in a vital industrial field.

Those interested in work previous to 1922 might begin by consulting the extensive bibliographies in Wallace G. Imhoff's *Pickling of Iron and Steel* (1929), the subject indices to *Chemical Abstracts*, and to the abstract section of the *Journal of the Iron and Steel Institute* (*London*).

EMORY C. SKARSHAUG

MAX PLANCK, SCIENTIFIC AUTOBIOGRAPHY AND OTHER PAPERS, translated from the German by Frank Gaynor. Published by Philosophical Library, Inc., New York, 1949. 192 pages, $3.75.

Any man of keen observation who has lived the past 90 years has witnessed perhaps one of the most spectacular scenes in history. To a philosophic mind, capable of the Nobel laureate in physics, and sensitive to human needs and happiness, these years might well represent a poignant experience. Such a mind was that of Max Planck, who completed his observations on October 7, 1947, but without despair.

One might wonder how full impressions of the past half century could engender any form of optimism, yet Max Planck arrived at the full maturity of his years with a serious hopefulness for the future. This, despite his witness to the meteoric rise of the German empire, where he was born, followed by its total eclipse and ghastly end. He lost one son in World War I and a second was executed as an anti-Nazi in 1945. His house and library were destroyed by an air raid during World War II. Yet in this interesting book, which collects his essays and lectures written in the latter part of his life, he records: "The individual has no alternative but to fight bravely in the battle of life, and to bow in silent surrender to the will of a higher power which rules over him. For no man is born with a legal claim to happiness, success, and prosperity in life. We must therefore accept every favorable decision of providence, each single hour of happiness, as an unearned gift, one that imposes an obligation. The only thing that we may claim for our own with absolute assurance, the greatest good that no power in the world can take from us, and one that can give us more permanent happiness than anything else, is integrity of soul, which manifests itself in the conscientious performance of one's duty." This statement of philosophy is the antithesis of the welfare state preached so vehemently by the leader of Germany who caused its final demise.

In science, Planck had a most brilliant career. He worked on thermodynamics for his thesis and early research, only to discover later that Willard Gibbs had preceded him in papers published obscurely in the Connecticut Academy. He later contributed to the thermodynamics of electrolytes, and formulated the equation well known to electrochemists for the potential difference at liquid junctions, and which Nernst confirmed experimentally. His greatest contribution was the concept of the quantum theory, applied first to explain radiation from hot bodies.

Despite the brilliance of these contributions in many fields, Planck was continually on the defensive with respect to his new ideas. Boltzmann, a bright star in the scientific world of that time, took personal offense at some of Planck's ideas, a prejudice that was removed only in the last years of Boltzmann's life. Perhaps this and other similar instances account for Planck's resigned conclusion that "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

In the autobiography we learn that Helmholtz, who was one of Planck's early teachers, never prepared his lectures and made many mistakes, and that Kirchoff prepared his lectures but was extremely monotonous. It is surprising to learn that Boltzmann's constant k was never introduced by Boltzmann nor did he ever investigate its numerical value, since the constant related to the atom, and Boltzmann was suspicious of the idea that atoms were real.

Although Planck lived in Germany throughout the Nazi regime, his viewpoint remained uncontaminated by the false ideas and the black-out of truth that prevailed during the 1930's. The last paragraph of this book ends with perhaps what was always his creed and outlook: "Religion and natural science are fighting a joint battle in an incessant, never relaxing crusade against scepticism and against dogmatism, against disbelief and against superstition, and the rallying cry in this crusade has always been, and always will be: *'On to God!'* " He spent the latter years of his life lecturing and philosophizing, finding great interest and satisfaction in both.

Perhaps it is self-evident from the above that this small book of less than 200 pages is a readable account of Planck's viewpoint of science and life. The translation is well done.

H. H. UHLIG

ANNOUNCEMENTS FROM THE PUBLISHERS

THE FUNDAMENTALS OF DETERGENCY by William W. Niven, Jr. Published by Reinhold Publishing Corp., New York, 1950. 256 pages, $5.50.

This book presents a well-planned picture of the principles of detergent

action, treating on the theory and practical applications of detergents. It is an important source to those engaged in such industries as foods, soap, textiles, rubber, printing, laundering, etc. Includes discussion of the effects of composition, concentration, temperature and added electrolytes on the nature and properties of aqueous solutions; the actions which constitute detergency and aids; the means of utilizing various detergent actions, etc.

WAVEFORMS edited by Britton Chance, Vernon Hughes, Edward F. MacNichol, David Sayre, Frederick C. Williams. Published by McGraw-Hill Book Co., Inc., New York, 1949. 785 pages, $10.00.

Compiled by the M.I.T. Radiation Laboratory. For those in industrial and academic laboratories this book presents the basic techniques used in the generation and manipulation of voltage and current by linear and nonlinear circuit elements. This wealth of material is classified according to circuit functions, beginning with the generation of simple waveforms, then the processes of amplitude and time analysis, modulation, demodulation, and frequency multiplication and division.

ELECTRONIC INTERPRETATIONS OF ORGANIC CHEMISTRY, 2nd edition, by A. Edward Remick. Published by John Wiley & Sons, Inc., New York, 1949. 600 pages, $6.00.

This book serves as a review of the field to give the reader a working knowledge of the subject. Explains the use of the electron theory as an aid in solving laboratory problems either in pure or applied chemistry. This edition contains nearly 100 new pages in addition to extensive revision of the old ones, and elimination of material not so pertinent to recent developments. Includes tables of basic principles and symbols.

RECENT NBS PUBLICATIONS

Copies of the following publications of the National Bureau of Standards may be obtained at listed prices from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Acidic Dissociation Constant of Ammonium Ion at 0° to 50°C, and the Base Strength of Ammonia, Roger G. Bates and Gladys D. Pinching, 12 pp., 10 cents (RP1982).

A study of the changes of free energy, heat content, entropy, and heat capacity that accompany the dissociation processes in the standard state are derived from the temperature coefficients of the acidic dissociation constant of ammonium ion and of the basis dissociation constant of ammonia.

Electrophoresis of Modified Collagen, James M. Cassel and Joseph R. Kanagy, 8 pp., 10 cents (RP2001).

Results of electric mobility measurements made on collagen samples modified by heating, water-shrinking, deaminizing, protracted ball-mill grinding, and several tanning processes.

Acid-Base Equilibrium Constants for the Reaction of Tribenzylamine with Picric Acid and with Trinitro-m-Cresol in Benzene, from Spectrophotometric Data, Marion Maclean Davis and E. Anne McDonald, 9 pp., 10 cents (RP1997).

Relative acidic strengths of picric acid and trinitro-m-cresol in benzene have been measured spectrophotometrically in terms of their reactivity with the base, tribenzylamine.

Properties of Calcium-Barium Titanate Dielectrics, Elmer N. Bunting, George R. Shelton, and Ansel S. Creamer, 8 pp., 10 cents (RP2025).

A study of the properties of dielectrics having compositions in the system $3CaO:TiO_2$-$BaTiO_3$-TiO_2 matured at 1,260° to 1,500°.

Low-Temperature Performance of Radiosonde Electric Hygrometer Elements, Arnold Wexler, 8 pp., 10 cents (RP2003).

The data indicated that an element measured relative humidity with an average deviation from the mean of ± 2.4 per cent relative humidity. The lag in response, in addition to showing a marked increase with decrease in temperature, was found to depend upon the magnitude and direction of relative humidity change, and the relative humidity from which the change was made.

Effect of Chromium Plating on the Endurance Limit of Steels Used in Aircraft, Hugh L. Logan, 12 pp., 10 cents (RP2011).

Report of an investigation of the effect of chromium plating on the endurance limit of steels used in aircraft, showing that chromium plating reduced the endurance limits of both normalized and hardened SAE X4130 steels.

LETTERS TO THE EDITOR

Dear Sir:

I wish to compliment you on the fine start you have made with the new style JOURNAL. It is something of which every member of the Society is very proud.

JOSEPH SCHULEIN
Corvallis, Oregon

Dear Sir:

I want to congratulate you and your co-workers on the excellent typography and content of the new JOURNAL. This JOURNAL will represent the high standards of the Society.

CHARLES W. TOBIAS
Berkeley, California

Dear Sir:

I have read with much interest the "Review of the Electrochemistry of Stressed Metals" by M. T. Simnad which appeared on page 31C of the February issue of the JOURNAL. Naturally I was most interested in the discussion "Internal Stresses in Electrodeposited Metals." Your readers may be interested in the fact that a number of papers dealing with or touching upon this subject have appeared in publications of the American Electroplaters' Society during the last few years. They are as follows:

1. B. MARTIN, "Stress in Electrodeposition of Nickel," *Proc. Am. Electroplaters' Soc.*, **32,** 206 (1944).
2. K. G. SODERBERG AND A. K. GRAHAM, "Stress in Electrodeposits—its Significance," *Ibid.*, **34,** 74 (1947).
3. W. M. PHILLIPS AND F. L. CLIFTON, "Stress in Electrodeposited Nickel," *Ibid.*, **34,** 97 (1947).
4. A. BRENNER AND C. W. JENNINGS, "Physical Properties of Electrodeposited Metals—Nickel," *Ibid.*, **35,** 31 (1948).
5. A. BRENNER AND S. SENDEROFF, "A Spiral Contractometer for Measuring Stress in Electrodeposits," *Ibid.*, **35,** 53 (1948).
6. W. M. PHILLIPS AND F. L. CLIFTON, "Judging the Quality of Plated Parts," *Ibid.*, **35,** 87 (1948).
7. H. J. READ AND J. H. THOMPSON, "Methods for Testing Thickness of Electrodeposits. Effect of In-

ternal Stress on Thickness Determinations by the Jet Method," *Ibid.*, **35,** 79 (1948); *Plating*, **35,** 922 (1948).

8. A. K. Graham and R. Lloyd, "Stress Data on Copper Deposits from Alkaline Baths," *Plating*, **35,** 449 (1948).
9. A. Brenner and S. Senderoff, "Calculation of Stress in Electrodeposits from the Curvature of a Plated Strip," *J. Research Nat. Bur. Standards*, **42,** 105 (1949), PR 1954; condensed in *Plating*, **36,** 810 (1949).
10. K. G. Soderberg and H. L. Pinkerton, "Antimony Plating," *Plating*, **37,** 248 (1949).

They may also like to know that reference 124 cited by Dr. Simnad was also published in the *Proceedings of the American Electroplaters' Society*, Vol. 32, p. 32 (1947).

Cracking of nickel-chromium coatings on outdoor exposure has been dealt with not only in some of the above mentioned papers but also in the report of Sub-committee II on Performance Tests of Committee B-8 on Electrodeposited Metallic Coatings of the American Society for Testing Materials which appears in Preprint 15, 1949 of that Society.

Gustav Soderberg
Editor, *Plating*
Jenkintown, Pennsylvania

NEW MEMBERS

At the meeting of the Executive Committee held on February 9, 1950, at the office of The Electrochemical Society, Inc., 235 West 102nd Street, New York City, the following were elected to membership:

Active Members

K. Krishna Ayar, The Aluminum Corporation of India, Ltd., Jaykaynagar, Burdwan, India (Electrodeposition)

Carlton M. Dean, Monsanto Chemical Co., 1700 S. 2nd Street, St. Louis 4, Missouri (Industrial Electrolytic)

Sally F. Dennis, Lubrizol Corporation, mailing add: 25101 Lake Shore Blvd., Euclid 23, Ohio (Electrodeposition)

Raymond W. Fenn, Jr., The Dow Chemical Company, mailing add: 4 Brown Court, Midland, Michigan (Corrosion and Electrodeposition)

Elbert H. Hadley, Southern Illinois University, mailing add: RFD 4, Chautauqua St., Carbondale, Illinois (Electrodeposition)

Jaroslav Heyrovsky, Physico-chemical Institute, Charles University, Albertov 2030, Prague II, Czechoslovakia (Theoretical Electrochemistry, Organic Electrochemistry, Electrodeposition, Electronics and Dielectrics)

George R. Kingsbury, The Cleveland Graphite Bronze Co., mailing add: 6799 Wilson Mills Road, Gates Mills, Ohio (Electrodeposition)

Erich H. Konrad, University of Vermont and State Agricultural College, mailing add: Harbor Road, Shelburne, Vermont (Electrodeposition and Industrial Electrolytic)

Guy W. Leonard, Jr., Kansas State College, Chemistry Dept., Manhattan, Kansas (Corrosion)

Charles H. Moore, Jr., National Lead Co., 111 Broadway, New York 6, N. Y. (Corrosion and Electrothermic)

Associate Member

Arnold I. Friedman, General Electric Co., mailing add: 2980 E. 132nd St., Cleveland 20, Ohio (Electronics)

MEETINGS OF OTHER ORGANIZATIONS

The American Society of Mechanical Engineers, spring meeting, Hotel Statler, Washington, D. C., April 12–14

Eastern Electrical Wholesalers Association, annual dinner dance, Hotel Astor, New York, April 29

American Electroplaters' Society, Indianapolis Branch, 7th annual educational session and dinner dance, Indianapolis Athletic Club, Indianapolis, Indiana, May 6

The American Society of Refrigerating Engineers, semi-annual meeting, Muehlbach Hotel, Kansas City, Missouri, June 4–7

Edison Electric Institute, 18th annual convention, Auditorium, Atlantic City, New Jersey, June 5–7

American Institute of Electrical Engineers, summer general meeting, Pasadena, California, June 12–16

American Society of Heating & Ventilating Engineers, semi-annual meeting, Muskoko Lakes, Ontario, Canada, June 19–21

NOTES FROM INDUSTRY

Personalities

International Graphite & Electrode Corporation has appointed two new representatives in the South. Ernest E. Graham, President of E. E. Graham & Company, will represent International in Texas, Oklahoma, and Louisiana. The Schuler Equipment Company, of which William M. Schuler is President, will represent International in Alabama, Arkansas, Tennessee, Mississippi, North and South Carolina, Georgia, and Florida.

Carlos Gonzenbach, Ecuadorian scientist, has joined the technical staff of the Pennsalt International Corporation to assist consumers in South and Central America in the uses of agricultural, sanitation, health, and industrial chemicals produced by the company.

Products

General Electric Company has announced the development of a new portable radiation detector, the long-probe Gamma Survey Meter, which enables the operator to measure radioactivity from a distance. The new instrument, developed by the G-E General Engineering and Consulting Laboratory, can be used for monitoring areas in which radioactivity is suspected or for other types of radiation metering. A detector located at the tip of a four-foot-long probe converts radioactive emanations into electrical energy. This detector consists of an electronic tube and a phosphor, a material which gives off light in the presence of radioactivity. Light from the phosphor acts upon the electronic tube, which converts the light energy into electrical energy and amplifies its magnitude.

Better Finishes and Coatings, Inc., is now shipping Chromic Acid Flake, Technical Grade, produced in newly installed electrochemical equipment at its Newark, New Jersey, plant. Analyses by independent testing laboratories indicate that the new production is low in chlorides, sulfate, and insolubles and exceeds U. S. Government Specification AN-A-21.

Industrial Filter & Pump Manufacturing Company of Chicago has introduced a line of water demineralizers. These demineralizers, which deliver the chemical equivalent of distilled water at only a small fraction

of the cost of distilled water, require no heat and no stills. The dissolved mineral salts in the water are removed by a simple chemical action and absorption in passing the water through beds of ion-exchange resins. This demineralization of water is recommended for such industries as soaps, ceramics, dyestuffs, enameling, distilleries, electroplating, pharmaceuticals, ice manufacture, papermaking, photographic processing, laboratory work, and for any product or process requiring water that is free from dissolved mineral salts. Further information and descriptive bulletins are available from the manufacturer.

Potter Instrument Company, Inc., is now offering a new Model 310 Photo-Electronic Counter which can be used at counting rates up to 6000 per minute. A completely self-contained package including a photo-electric detector, one

electronic decade, and a six digit electromechanical register, the new counter is intended for industrial applications in which mechanical counters do not count accurately, or wear rapidly because of counting speed. The light source is in a small separate housing providing the greatest degree of mounting flexibility. Through the use of the electronic counter decade ahead of the electromechanical register, the counting speed of the mechanical counter is scaled down by a factor of 10 thereby increasing the reliability and accuracy. For complete information write to Potter Instrument Company, Inc., 136–56 Roosevelt Avenue, Flushing, New York.

EMPLOYMENT SITUATIONS

Please address replies to box shown, c/o The Electrochemical Society Inc., 235 West 102nd Street, New York 25, N. Y.

Positions Wanted

Technical Service, Research, or Development: B.S. in Ch.E. 1939. Electrochemical experience: quality control, research, development, production, administration. 2½ years industrial electroplating. Dry batteries, 4 years Signal Corps Dev. Labs., 3½ years industrial. Practical mechanic. Desires interesting permanent position with responsibility and advancement. *Reply to Box 337.*

Electrochemist: Ph.D. 12 years' broad experience covering research, development, technical supervision in electrodeposition of metals and alloys, electroplating, batteries, theoretical electrochemistry, metal protection, and corrosion. Papers and awards. Can initiate and carry out research program. Desires academic or permanent responsible position. Location immaterial. Available immediately. *Reply to Box 338.*

Dry Battery Plant Superintendent, Graduate Chemical Engineer, over 25 years experience in all aspects of Dry Battery operations. Until recently associated with one of the largest organizations in the country as plant superintendent. Holds several patents for Dry Battery products; co-patentee of nationally known Dry Battery specialty. No preference as to location. *Reply to Box 339.*

RECENT PATENTS

Selected for electrochemist by Fred. W. Dodson, Chairman of the Patent Committee, from the Official Gazette.

November 22, 1949

Cross, C., 2,488,711, High-Current Battery-Charging System

Dahlman, V., 2,488,712, Electrical Dust-Precipitating Unit

Elenbaas, W., 2,488,716, Electric High-Pressure Discharge Tube

Froelich, H. C., 2,488,719, Magnesium Pyrophosphate Phosphor

Klasens, H. A., and Holmes, T., 2,488,727, Electrode for Electric Discharge Devices

Lambert, G. J., and Padmos, A. A., 2,488,731, Electron-Emitting Electrode for Electric Discharge Tubes

McKeag, A. H., and Ranby, P. W., 2,488,733, Alkaline Earth Halophosphate Phosphors

Charlin, A. M. B., 2,488,763, Electrochemical Condenser

Few, W., 2,488,856, Automatic Electric Regulation of Electroplating Apparatus

Kharasch, M. S., 2,489,091, Production of Organic Phosphorus Compounds

November 29, 1949

Clifton, F. L., 2,489,523, Electrodeposition of Tin or Lead-Tin Alloys

Phillips, W. M., and Clifton, F. L., 2,489,538, Electrodeposition of Copper

Bialosky, J. M., 2,489,739, Electrolytic Water Correction Device

Klemperer, H., 2,489,786, Electrical Precipitator

Hull, A. W., 2,489,891, Cesium Electric Discharge Device

December 6, 1949

Hoff, C. M., 2,490,055, Metal Strip Electroplating Apparatus

Jernstedt, G. W., 2,490,062, Cleaning and Activating Compositions and Use thereof in Producing Protective Phosphate Coatings on Metal Surfaces

Munger, H. P., 2,490,084, Method of Controlling Flow Brightening of Plated Metal Articles

Strickland, H. A., Jr., 2,490,104, Apparatus for Equalized Induction Hearing of Workpieces

Strickland, H. A., Jr., 2,490,105, Electric Furnace Cooling System

Strickland, H. A., Jr., 2,490,106, Induction Heating Furnace Construction

Strickland, H. A., Jr., 2,490,107, Hood and Coil Arrangement for Induction Furnaces

Beach, R. H., 2,490,196, Base Metal Thermopile

Hensel, F. R., and Larsen, E. I., 2,490-214, Electrical Contacting Element

Jaffe, H., 2,490,216, Piezoelectric Crystal

De Voe, C. F., 2,490,339, Electric Glass Melting Furnace and Process

Anicetti, R. J., 2,490,570, Pyrophoric Alloys of Lead and Zirconium and Sparking Devices Containing the Same

Anicetti, R. J., 2,490,571, Pyrophoric Alloy of Zirconium, Lead, and Titanium, and Sparking Device Containing the Same

Keene, P. A., 2,490,634, Apparatus for Controlling the Concentration of Solutions which Tend to Foam

PHYSICAL SCIENCE ASSOCIATES
DIRECTORS: G. H. KISSIN AND NORMAN BAUER
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